Danaher Motion

SERVO**STAR**® PD

Installation Manual

KOLLMORGEN

giving our customers freedom of design

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Safety Instructions

Only qualified personnel are permitted to transport, assemble, commission, and maintain this equipment. Properly qualified personnel are persons who are familiar with the transport, assembly, installation, commissioning and operation of motors, and who have the appropriate qualifications for their jobs. The qualified personnel must know and observe the following standards and regulations:

IEC 364 resp. CENELEC HD 384 or DIN VDE 0100
IEC report 664 or DIN VDE 0110
National regulations for safety and accident prevention or VBG 4

Read all available documentation before assembly and commissioning. Incorrect handling of products in this manual can result in injury and damage to persons and machinery. Strictly adhere to the technical information on the installation requirements.

It is vital to ensure that all system components are connected to earth ground. Electrical safety is impossible without a low-resistance earth connection.

The SERVO**STAR**® product contains electro-statically sensitive components that can be damaged by incorrect handling. Discharge yourself before touching the product. Avoid contact with high insulating materials (artificial fabrics, plastic film, etc.). Place the product on a conductive surface.

During operation keep all covers and cabinet doors shut. Otherwise, there are deadly hazards that could possibility cause severe damage to health or the product.

In operation, depending on the degree of enclosure protection, the product can have bare components that are live or have hot surfaces. Control and power cables can carry a high voltage even when the motor is not rotating.

Never pull out or plug in the product while the system is live. There is a danger of electric arcing and danger to persons and contacts.

After powering down the product, wait at least ten minutes before touching live sections of the equipment or undoing connections (e.g., contacts, screwed connections). Capacitors can store dangerous voltages for long periods of time after power has been switched off. To be safe, measure the contact points with a meter before touching.

When these symbols are seen in this manual, be alert to the potential for personal injury. Follow the recommended precautions and safe operating practices included with the alert symbols. Safety notices in this manual provide important information. Read and be familiar with these instructions before attempting installation, operation, or maintenance. The purpose of this section is to alert users to possible safety hazards associated with this equipment and the precautions that need to be taken to reduce the risk of personal injury and damage to the equipment. Failure to observe these precautions could result in serious bodily injury, damage to the equipment, or operational difficulty.

The safety-alert symbols are:

Warning Alerts users to potential physical danger or harm. Failure to follow warning notices could result in personal injury or death.

Caution Directs attention to general precautions, which if not followed, could result in personal injury and/or equipment damage.

Note Highlights information critical to your understanding or use of the product.

Directives and Standards

The SERVO**STAR** PD product series have been successfully tested and evaluated to meet UL/cUL 508C for both U.S. and Canadian markets. This standard describes the fulfillment by design of minimum requirements for electrically operated power conversion equipment, such as frequency converters and servo amplifiers, which is intended to eliminate the risk of fire, electric shock, or injury to persons, being caused by such equipment.

CE Mark Conformance

Servo drives are components that are intended to be incorporated into electrical plant and machines for industrial use. When the servo drives are built into machines or plants, drives cannot be operated until the machine or plant fulfills the requirements of the EC Directive on Machines 89/392/EEC and the EC Directive on EMC (89/336/EEC). EN 60204 and EN 292 must also be observed.

In connection with the Low Voltage Directive 73/23/EEC, the harmonized standards of the EN 50178 series are applied to the amplifiers, together with EN 60439-1, EN 60146 and EN 60204.

The manufacturer of the machine or plant is responsible for ensuring that they meet the limits required by the EMC regulations. Advice on the correct installation for EMC - such as shielding, grounding, arrangement of filters, treatment of connectors and the laying out of cabling - can be found within this documentation.

Conformance with the EC Directive on EMC 89/336/EEC and the Low Voltage Directive 73/23/EEC is mandatory for the supply of servo drives within the European Community.

An authorized testing laboratory in a defined configuration with the system components has tested the servo drives. Any divergence from the configuration and installation described in this documentation means that you are responsible for the performance of new measurements to ensure that the regulatory requirements are met.

Danaher Motion Kollmorgen's PD-Series systems have been successfully tested and evaluated to the limits and requirements of the EC Directive on EMC (89/336/EEC) and the EC Directive on Low Voltage (72/73/EEC). The product lines have been evaluated to EN50178 and EN60204 as a component of a machine and other relevant standards.

The EMC of a system can be identified by emissions and immunity. Emissions refer to the generation of EMI (electromagnetic interference) and immunity refers to the susceptibility levels of the equipment. Limits were derived from generic standards EN55081-2 and EN55082-2 for heavy industrial environments. The SERVO**STAR** PD-series drives have been tested for radiated emissions, conducted emissions, EFT, ESD, surge, conducted immunity, and radiated immunity. These tests have been done in accordance with EN55011, EN61000-4-2, ENV50140, IEC 1000-4-4, EN61000-4-5, and ENV50141.

Installation of the equipment is critical in designing for system and machine electromagnetic compatibility (EMC). You must apply the installation recommendations and the CE filtering Practices when mounting and installing the drive system for CE conformance.

Customer Support

Danaher Motion Kollmorgen technical documentation is updated periodically and may be changed without notice. The latest documentation can be found on our website. For information on this product or where to purchase near you, contact: your local distributor. To locate a distributor near you, visit the website (www.danahermotion.com).

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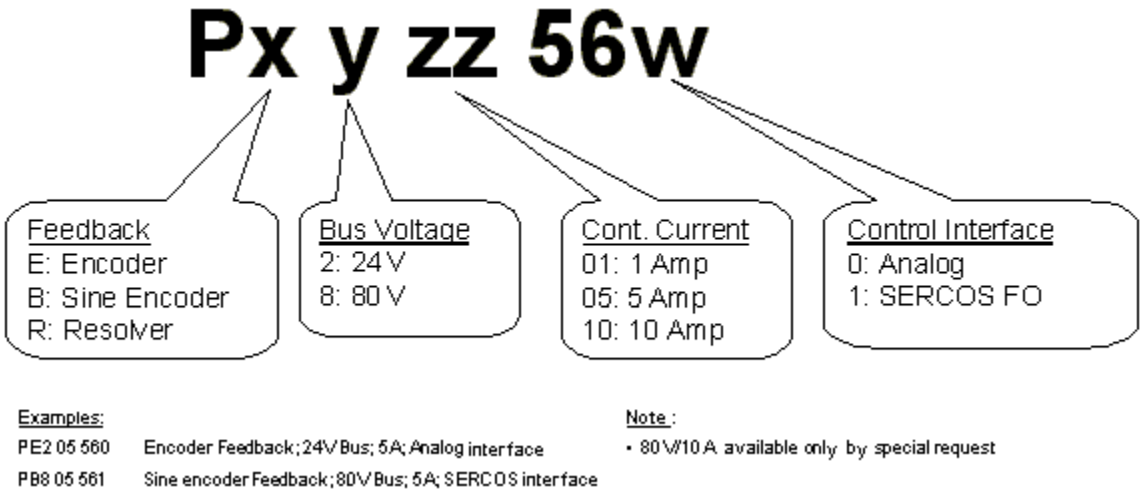
SYSTEM DESCRIPTION

The SERVO**STAR**® PD is a high-performance servo drive that can operate in Torque, Velocity and Position modes. It comes in a miniature package measuring only 140 mm (4.1 in.) x 108 mm (4.25 in.) x 51 mm (2 in.). Numerous position control options are offered, ranging from the classical ±10 VDC command, through encoder following and pulse/direction, all the way to SERCOS interface® control. The SERVO**STAR** PD comes in standard packages of 5 and 10 amps continuous current, and supports nominal bus voltages from 24 VDC through 80 VDC. It has its own tailored software environment in Danaher Motion Kollmorgen's **MOTIONLINK**® for Windows.

The SERVO**STAR** PD includes a vast array of features. Its various control techniques, interfaces, and user tools give you a compatible drive to meet most motion control applications.

Bulleted words that begin in capital letters indicate formal feature names. Words that are capitalized indicate the software variables and commands associated with the feature. This section is designed to direct you to the VarCom Reference Manual for details on these features.

PART NUMBER



FRONT PANEL CONNECTOR LOCATIONS

- PI: 24 VDC Logic Power
- P2: Motor power output
- P3: Bus voltage input
- C1: Serial Communications
- C3: I/O

SIDE PANEL CONNECTOR LOCATIONS

The right-hand side panel of the PD has two versions, one for the PD with that works with an Analog command signal (±10 VDC), and one for the PD with SERCOS interface®. The difference is that the Analog command version has an Equivalent Encoder Output connector, while the SERCOS interface version has SERCOS interface connectors.

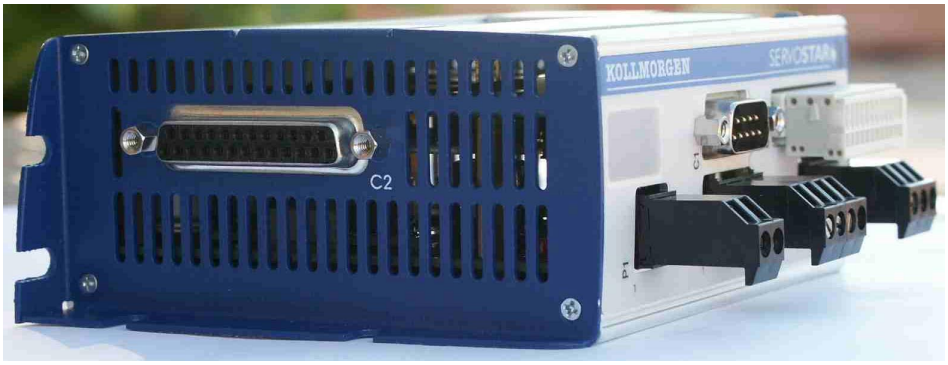
The picture below shows the side panel for the Analog command PD.

- C4: Equivalent Encoder Output
- C8: Secondary encoder input

Fiber optics connectors are mounted in the C4 location for the SERCOS interface option, as shown below.

- C4: Equivalent Encoder Output
- C8: Secondary encoder input

The feedback connector, C2, is located on the left-hand side panel, as shown in the picture below.



GENERAL FEATURES

- Many enabling and disabling features (K, S, STOP, REMOTE, EN, DIS).
- Flash firmware memory for easy field upgrade installation.
- Danaher Motion Kollmorgen's patented "Torque Angle Control" for buried magnet motor designs (MTANGLC, MTANGLP, MTANGLF, MTANGLH - defined as speed and torque optimization through commutation angle advancing of the drive's output current waveform with respect to the motor's back EMF waveform.
- Firmware and serial number information (VER, SERIALNO) via terminal.
- Encoder Equivalent Output signal (C4 connector) eliminates the need for an additional position feedback device. The maximum frequency of this output is 3 MHz for standard encoders.

FAULT AND SAFETY DETECTION

- Fatal and non-fatal error coding with text explanation to the host (ERR, FLTHIST, FLTCLR). A run-time counter (TRUN) that records the time the error occurred is also provided.
- Faults status word (STAT, STATUS).
- Configurable under-volt protection (UVMODE, UVTIME, UVRECOVER).
- Configurable motor thermal protection that accepts various thermostat types (THERM, THERMODE, THERMTYPE, THERMTIME).
- Configurable drive thermal protection through the fold-back feature (FOLD, FOLDMODE). It sets the maximum time limit the drive can provide peak current to the motor.
- Configurable motor thermal protection through the motor fold-back feature (MFOLD, MFOLDD, MFOLDDIS, MFOLDR, MFOLDT). It sets the maximum time limit the drive can provide continuous current to the motor.
- Speed and current protection (VOSPD, VLIM, ACC, DEC, ILIM, ILIM2).
- Hardware position limit switch detection (CCWLIM, CWLIM, LIMDIS, IN1, IN2, IN3, IN1MODE, IN2MODE, IN3MODE).
- Configurable software position limits (PLIM, PMAX, PMIN, PEMAX).
- Configurable fault relay output (RELAY, RELAYMODE, DISTIME, IN1MODE, IN2MODE, IN3MODE).
- Active disable feature (ACKFAULT) that allows you to determine how the system should react at the occurrence of a fault. The system can immediately disable, where the motor will coast to a stop, or it can be programmed to a controlled decelerated stop (DECSTOP, DISSPEED, DISTIME, STOPMODE, ISTOP).
- Active enable indicator through the Status Display decimal (ACTIVE, DRIVEOK, SWEN, READY, REMOTE, DIPEN).
- Watchdog faults.

FEEDBACK DEVICES

Encoders

- Maximum frequencies to 3 MHz before quad.
- Up to 10 million lines per motor mechanical cycle (MENCRES).
- Encoder-based systems: actual encoder signals are exported through this output (MENCRES) and can be scaled down by multiples of two (ENCOUTO).
- Configures automatically (ENCINIT, ENCINITST, ENCSTART, IENCSTART, INITMODE).
- Index pulse offsetting capability (MENCOFF).
- Variety of encoder types (MENCTYPE):
  1. Encoder with or without index.
  2. Encoder-hall effects with or without index (MHINVA, MHINVB, MHINVC, HALLS).
- Wake-No-Shake: Encoder initialization with very little motion when working without halls or commutation tracks

Resolvers

- Variety of motor and resolver pole combinations (MPOLES, MRESPOLES).
- Resolver-zero offsetting (MPHASE).
- System accuracy's better than 20 arc minutes (reduced when resolver pole count is increased).
- 18-bit velocity control and 16-bit positioning capability.

Sine Encoders

- Up to 4096x internal interpolation (MSININT)
- Up to 128x encoder equivalent output (SININTOUT).
- Most standard encoder features mentioned above.
- Support for Heidenhain EnDat® and for Stegmann Hiperface® encoders. The Hiperface encoders must work with a 5 V supply.

Halls-Only

- The PD can drive a motor with Halls-only feedback (MENCTYPE 5)

MONITORING AND TROUBLESHOOTING TOOLS

- Performance recording (RECDONE, RECING, RECOFF, RECORD, RECRDY, RECTRIG).
- System status checking (STAT, STATUS, STATUS2).
- Control loop monitoring:
- Current/torque (I, IA, IC, ICMD, IMAX, ICONT, DICONT, DIPEAK).
- Speed (V, VCMD, VE).
- Position (PCMD, PFB, PE, HALLS, HWPOS, INPOS, PRD, PEXT, PEINPOS).
- Dual-state digital output (O1, O1MODE, O1RST, O1TRIG) that toggles according to various absolute current, speed, and position parameter settings. Also can be used to communicate occurrences of fold-back, motor braking, and the status of the Remote Enable hardware switch.
- Status Display (TESTLED) indicator that communicates operational and fault characteristics.
- Realtime reading of the 10-position DIP switch (DIP, DIPEN).
- Software status switch indicator provided for configurable inputs (IN1, IN2, IN3, IN1MODE, IN2MODE, IN3MODE).

SYSTEM COMMUNICATIONS

- Serial communications port (address setting through DIP switch on top of drive).
  - RS-232.
  - Data transmission (DUMP, GET, LIST, MLIST, GETMODE) baud rates of 9600 or 19200.
  - Configurable protocol (ECHO, PROMPT, ACKMODE, GETMODE, MSG).
  - Interface through Danaher Motion Kollmorgen's **MOTIONLINK** or a dumb terminal.
- Differential analog input command (ANIN).
  - ±10 V at 14 bit resolution.
  - ±10 V at 15 bit resolution below 4 V of input for slow speed operation using the Dual Gain feature (ANDG - SE units only).
  - Input signal filtering (ANLPFHZ).
  - Flexible analog input scaling (VSCALE, ISCALE, ANOFF, ANZERO, ANDB).
- SERCOS interface communications port (SERCOS versions only).
  - 2-ms update rate.
  - Complete set of manufacturer's IDNs.
  - **MOTIONLINK** communication through the serial port.

MOTIONLINK SOFTWARE ENVIRONMENT

- Easy setup, commanding, and monitoring techniques.
- Contains an extensive database for many of Danaher Motion Kollmorgen's motor series.
- A backup screen that provides automatic loading of system parameters.
- Realtime metering of many system parameters.
- PC scope feature for profile recording and realtime motion performance measuring.
- Optional terminal mode feature for keystroke commanding and monitoring.
- Status screen indicating system operation and fault/error checking.
- Extensive on-line help file (F1) designed to assist you in **MOTIONLINK**'s intuitive nature.
- A set of limits folders allowing you to manipulate the position, velocity, current, and filtering limits from one screen.
- An I/O screen for easy manipulation of the drive's I/O, thermostat options, encoder output, and hardware position limits capabilities.
- A feedback device screen that provides realtime pictorial positioning information. It also includes an encoder initialization folder.
- A tuning screen designed to allow you to adjust control loop gains quickly while visibly watching the affects on performance.
- A control loops screen that provides direct manipulation of velocity and position loop gain parameters.

MOTOR CONTROLLABILITY

- Provides linear and rotary motor control (MOTORTYPE, MPITCH, MENCRES) with automatic unit conversion.
- Configurable back EMF characteristics for effective current loop controller design and command (MBEMF, MBEMFCOMP).
- Danaher Motion Kollmorgen's patented Torque Angle control to maximize motor output power (MTANGLC, MTANGLP, MVANGLF, MVANGLH).
- Motor speed and current limits (MSPEED, MICONT, MIPEAK).
- Thermal protection control (MFOLD, MFOLDD, MFOLDDIS, MFOLDR, MFOLDT) adaptable to any motor.
- Auto-configuration feature (ACONFIG, ACONFIGST, MFBDIR) automatically configures the motor's power and feedback cables. It checks, warns, and corrects for incorrect wiring of these cables.
- Configurable positive motion direction (DIR).

CURRENT/TORQUE CONTROL

- Digital current loop control (Torque Mode - OPMODE 2 or 3) receiving serial (T) or analog commands.
- Pulse Width Modulated (PWM) sine wave commutation (PWMFRQ) providing smooth and precise low-speed control and high-speed performance.
- Current loop adaptive gain (MLGAINC, MLGAINP, MLGAINZ).
- System current-limiting capability (ILIM, ILIM2, IMAX, MICONT, MIPEAK).
- Exponential current vs. Time limiter (FOLD, FOLDMODE).
- Back EMF compensator (MBEMFCOMP).

VELOCITY CONTROL

- Digital velocity loop control (Velocity Mode - OPMODE 0 or 1) receiving serial (J), analog (ANIN), or I/O triggered commands (MISPEED1, MISPEED2, MISPEED3, IN1, IN2, IN3, IN1MODE, IN2MODE, IN3MODE).
- Velocity stepping and jogging capability (STEP, J).
- Serial control through stored commands triggered through the Configurable I/O (IN1, IN2, IN3, IN1MODE, IN2MODE, IN3MODE).
- Automatic control loop tuning through the auto-tune feature (TUNE).
- Configurable application and system speed limits (VLIM, VOSPD, VMAX).
- Advanced control algorithms (COMPMODE):
- Proportional-Integral (GV, GVI).
- Pseudo-Derivative with feed forward (KV, KVI, KVFR).
- Standard Pole Placement (BW, MJ, LMJR, TF).
- Extended Standard Pole Placement (BW, MJ, LMJR, TF).
- First- and second-order low pass filtering capability (FILTMODE, LPFHZ1, LPFHZ2, COMPFILT).
- Notch filtering capability (FILTMODE, NOTCHHZ, NOTCHBW).

- Bandwidths up to 400 Hz.
- "On-the-fly" homing capability (HOMETYPE) in analog velocity mode (OPMODE 1) through either the Configurable Inputs or terminal.
- "On-the-fly" switching between velocity and current/torque control (IN1, IN2, IN3, IN1MODE, IN2MODE, IN3MODE).

POSITION CONTROL

- Serial positioning loop control (Position Mode - OPMODE 8 & PCMDMODE) receiving serial or I/O-controlled command (IN1, IN2, IN3, IN1MODE, IN2MODE, IN3MODE).
- Analog positioning loop control (Position Mode - OPMODE 8 & PCMDMODE) over a ±10 V range with scaling capability (PSCALE, GEAR, GEARI, GEARO) and I/O triggering.
- Incremental and absolute positioning with an "in position" indicator (MI, MA, INPOS, PEINPOS).
- Simple absolute and incremental indexing with I/O triggering capability (MAPOS, MASPEED, MIDIST0, MIDIST1, MIDIST2, MIDIST3, MISPEED0, MISPEED1, MISPEED2, and MISPEED3) through either the serial port or the hardware configurable inputs (IN1, IN2, IN3, IN1MODE, IN2MODE, IN3MODE).
- Position homing with I/O triggering capability (MH, HOMESPD, HOMESTATE, HOMETYPE) through either the serial port or the configurable inputs (IN1, IN2, IN3, IN1MODE, IN2MODE, IN3MODE).
- Electronic Gearing (Position Mode - OPMODE 4) featuring pulse following or master encoder capability with resolution up to 3 MHz through C8 connector (2.5 kHz through opto-isolators in C3) (GEAR, GEARMODE, GEARI, GEARO, PEXT, PEXTOFF, VEXT, XENCRES, XENCDIR). Homing capability is provided.
- Dual-loop mode (DUALFB) capable of positioning from a load feedback (C8 input, PEXTOFF, PEXT, VEXT, XENDIR) device while controlling velocity and torque from the motor feedback (C2 input).
- PID position loop tuning (GP, GPD, GPI,) with feed-forward acceleration gain input to both the velocity and current loops (GPAFR, GPAFR2), and feed-forward velocity gain input to the velocity loop (GPVFR).
- Software position limits (PLIM, PMAX, PMIN, PEMAX).
- Configurable integrator dynamics through travel range (GPISATOUT, GPISATIN).
- Cumulative, revolution, and error position counters (PFB, HWPOS, PRD, PE).
- Position indicators (INPOS, PEINPOS, PE, PEMAX, PFB, PFBOFF).

PROFILE RAMPING CONTROL

- Electronic Braking (STOPMODE, ISTOP).
- Separate ACCEL and DECEL linear ramping control in velocity and position mode (ACC, DEC, PROFMODE).
- S-curve ACCEL and DECEL ramping control (PROFSCRV, PROFMODE) in the position mode (OPMODE=8).
- Controlled decelerating (DECSTOP, DISSPEED, DISTIME) with acceleration feed-forward when the drive is left enabled (STOP, HOLD, CWLIM, CCWLIM, LIMDIS) or becomes disabled (K, S, ACKFAULT, DIS). This feature can be used in conjunction with the Electronic Braking feature.
- Torque compensator for coulomb friction and weight counter-balancing (IFRIC, IGRAV).

INSTALLATION QUICK STEPS

High voltage can present dangerous and hazardous conditions if not performed by a qualified electrician. Be certain to follow all national and local codes during installation. Follow all safety precautions outlined in the front of this documentation.

Open the box(es) and remove all the contents. Check to ensure there is no visible damage to any of the equipment.

Electronic components in this amplifier are design-hardened to reduce static sensitivity. However, proper procedures should be used when handling to avoid damage to equipment.

Remove all packing material and equipment from the shipping container. Be aware that some connector kits and other equipment pieces may be quite small and can be accidentally discarded if care is not observed when unpacking the equipment. Do not dispose of shipping materials until the packing list has been checked.

Upon receipt of the equipment, inspect components to ensure that no damage has occurred in shipment. If damage is detected, notify the carrier immediately. Check all shipping material for connector kits, documentation, diskettes, CD-ROM, or other small pieces of equipment.

- Mount the SERVO**STAR**® PD to the back panel. **Metal-to-metal contact is important for electrical noise control!**
- Wire the PD according to the Wiring Instructions. Pay particular attention to the pinout connector details.
  - Connect solid earth ground to frames of all components.
  - Wire the logic power (24 VDC) to connector P1. Refer toPI: Logic Power Connector for connection polarity.
  - Wire the motor to connector P2 (P2: Motor Power Connector).
  - Wire the 24 volt or 80 volt Bus power supply to connector P3 (24 VDC(Pico24) or 80 VDC (Pico80)). Refer to P3: Bus Power Connector for connection polarity.
  - Wire user I/O at connector C3: At a minimum, 24 volts must be brought in to the enable circuit between pins 6 and 7. Refer to C3: User I/O Connector. Be certain that connector C3 is inserted correctly.
  - Wire the motor feedback to connector C2 (C2: Feedback Connector). Refer to the Feedback Diagram for additional information.
  - Verify that all wiring is correct. Verify that earth grounds are connected. Verify all electrical and safety codes are met.
  - Connect the serial cable to connector C1 and to your PC.
  - Install **MOTIONLINK**® on the PC. **MOTIONLINK** can be found either on the website (www.danahermotion.com) or on the Product Support Package CD-ROM.

Startup processes can cause motor motion. Be certain that all applicable safety precautions are taken to ensure that no harm to personal or machine can occur.

- Using the Startup Wizard in **MOTIONLINK**:
  - Configure the PD for your particular motor, if this was not done at the factory.
  - Tune the PD for the load and desired performance.

24 volts must be present at the C3 enable input to get power to the motor.

  - Enable the system.

ELECTRICAL SPECIFICATIONS

The environment that any electronic control system 'lives' in can effect its operation. Danaher Motion Kollmorgen recommends that the SERVO**STAR** PD be operated and stored under the environmental conditions stated in the product's electrical specification tables. The system may be operated in higher temperature ambient conditions with a derating applied. Check with the factory for derating information.

Attention to proper installation and field wiring are of prime importance to ensure long-term and trouble-free operation. Users should familiarize themselves with and follow the installation and wiring instructions listed in this document. In addition to these practices, some localities and industries may require applicable electrical and safety codes, laws, and standards.

Product Model		PE205	PE805	PE210
Main Input Power	KVA at 24V	0.144		0.288
	Continuous Current (amps) at 24 V	6		12
	Peak Current (amps) for 500 mSec 24 V	12.5		25
	Peak Current (amps) for 2 Sec 24 V	12.5		25
	KVA at 80 V		0.48	
	Continuous Current (amps) at 80 V		6	
	Peak Current (amps) for 500 ms at 80 V		12.5	
	Peak Current (amps) for 2 s at 80 V		12.5	
	Line Fuses (FRN-R, LPN, or equivalent)(A)	15		30
Logic Input Power	+24 VDC Ext. Logic Voltage (volts)	22 - 27		
	+24 VDC Ext. Logic Current (amps sink)	0.6		
SoftStart	Max. Surge Current (amps)	30		
	Max. Charge Time (sec)	0.25		
Protection Functions	Fault Contact Rating (A)	1		
	Fault Contact Closing Period (ms)	Close = 3, Open = 2		
	OverTemperature trip (°C)	80		
	UnderVoltage Trip (nominal) (VDC)	16	40	16
	OverVoltage Trip (VDC)	56	100	56
Main Output (Ma, Mb, Mc)	Continuous Power (KVA) at 24 V Input (45° Ambient)	0.13		0.26
	Continuous Power (KVA) at 80 V Input (45°C Ambient)		0.433	
	Continuous Current (Arms)	5		10
	Peak Current (Arms) for 500 ms	10		20
	Peak Current (Arms) for 2 s	10		20
	PWM Frequency (kHz)	16		16
	PWM Motor Current Ripple (kHz)	32		32
	Form Factor (RMS/avg)	≤1.01		
Environment	Operation temperature) (°C)	5 to 45		
	Storage temperature (°C)	0 to 70		
	Ambient humidity (%)	10% to 90%		
	Atmosphere	without corrosive gasses or dust		
	Altitude	Derate 5% per 1000-ft (300 m) above 3300-ft (1000 m)		
	Vibration (g)	0.5		

MOUNTING

The SERVO**STAR** PD is designed for brick mounting. This panel assembly is then mounted in a metallic enclosure. Enclosures are supplied by the manufacturers of the final product and meet the environmental IP rating of the end product. To ensure proper grounding (and to optimize EMC), the enclosure should have continuous ground continuity maintained between all metal panels. This ground continuity is intended to be both a safety ground and a high frequency ground.

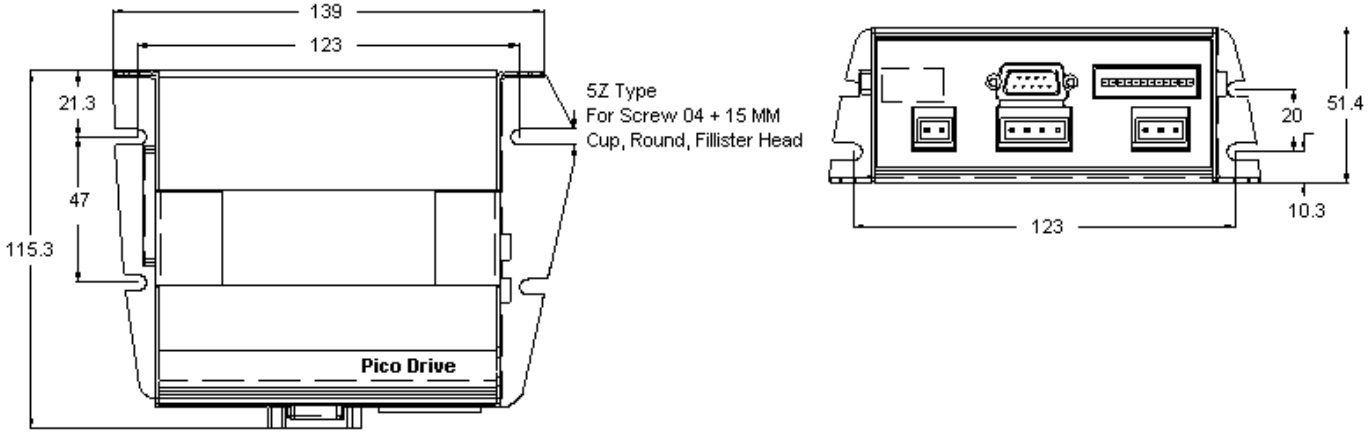
The units are mounted on a backplane installed into the enclosure. Ideally, the backplane should be an unpainted metallic surface to optimize electrical bonding of the frame and provide the lowest possible impedance path to earth ground. These enclosures also provide added safety.

Particular care should be used when layout of an enclosure is designed. Separate power wires from small signal wires. The following guidelines highlight some important wiring practices to implement:

- Control and signal cables must be separated from power and motor cables. Distance of 20 cm (8 in.) is sufficient in most cases.
- Control and signal cables must be shielded to reduce the effects of radiated interference.
- When control cables must cross power or motor cables, they should cross at an angle of 90°, if possible. This reduces the field coupling effect.

OUTLINE DIMENSIONS

Units are given in mm.



HARDWARE SPECIFICATIONS

Amplifier Model		PE2	PE8
Unit Weight	Lbs / Kgs	1.22/0.55	1.22/0.55
Mounting Hardware	Metric	22x8 conic screw	
	Applied Torque	20 lb-in (2.26 N-m)	
Mating Connector Hardware	C1	EDA 8S0009SS402S25 Connector 9 pins D type for Cable solder	
	C2	EDA 8S0025SS402525 Connector 25 pins D Type For Cable solder	
	C4	EDA 8S0009PS401S25 Connector 9 pins D Type For Cable solder	
	C8	EDA 8S0009SS402S25 Connector 9 pins D type for Cable solder	
	C3	Vendor Info: WAGO 733-112 2.5mm pin spacing Combicon 12 pins female connector Cat.No. 733-112	
	P1	PCD ELFF02130 Terminal Block 2 pins FEMALE	
	P2	PCD ELFF04130 Terminal Block 4 pins FEMALE	
	P3	PCD ELFF03130 Terminal Block 3 pins FEMALE	
Wire Size (AWG#)	Control Logic (AWG/ mm^2)	28 – 16 / 0.5 – 1.5	
	Motor Line (AWG/ mm^2)	18 – 16 / 0.8 – 1	16– 14 / 1 – 1.5
	Bus Input (AWG/ mm^2)	14 / 1.5	12 / 2.5
	I/O wire gauge	28-20 AWG (0.08-.0.5 mm^2)	
Clearance Distance	Side-to-Side	At least .1in (2.54 mm)	
	Top/Bottom	2.5 in (63.5 mm)	

WIRING INSTRUCTIONS

GROUNDING

System grounding is essential for proper performance of the drive system. A ground bus bar may be used as a single point ground for the system. Safety grounding should be provided to all pieces of the system from a “star point." In addition to the safety grounding, a high frequency ground must be provided that connects the back panel to the enclosure and, ultimately, to earth ground. The objective is to provide an extremely low impedance path between the filters, drives, power supplies, and earth ground. This high frequency ground is accomplished with the use of a flat braid or copper bus bar. It is important not to rely on a standard wire for the high frequency ground. In general, a wire has an inductance of 8nH-per-inch, regardless of diameter. At higher frequencies, this unwanted inductance between grounds equates to limited filter performance. When connecting high frequency grounds, use the shortest braid possible.

BONDING

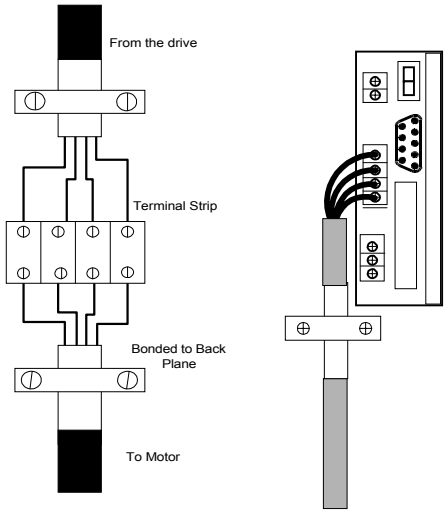
The proper bonding of shielded cables is imperative for minimizing noise emissions and increasing immunity levels of the drive system. Its effect is to reduce the impedance between the cable shield and the back panel. Danaher Motion Kollmorgen recommends that all shielded cables be bonded to the back panel.

Power input wiring does not require shielding (screening) if the power is fed to the cabinet (enclosure) via metallized conduit. If the metallized conduit is used with proper high frequency grounds, bonding technology, and recommended wire routing, then power input wire shielding has no affect. In the event that metallized conduit is not implemented into the system, shielded cable is required on the power input wires and proper bonding technologies should be implemented.

The motor and feedback cables should have the shield exposed as close to the drive as possible. This exposed shield is bonded to the back panel using one of the two suggested methods described in this manual.

Non-insulated Cable Clamp

The following figures shows how cable bonding is implemented using non-insulated metallic cable clamps. The first figure demonstrates clamping to the back panel in the vicinity of the drive. The second shows a technique for bonding a terminal strip (for best results, it is recommended not to break the shielding of the cable).



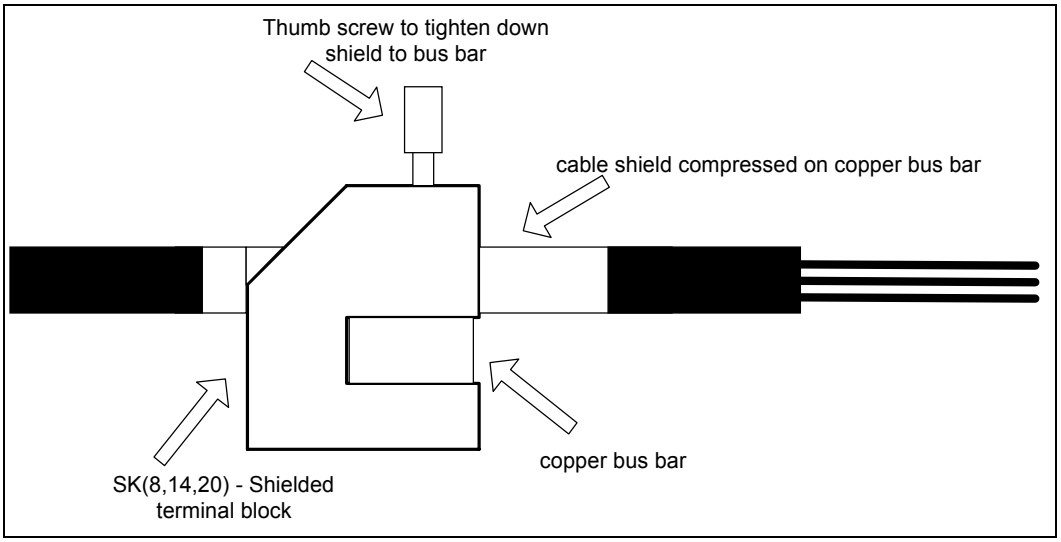
Terminal Clamp and Power Block Clamp

Alternative Bonding Methods

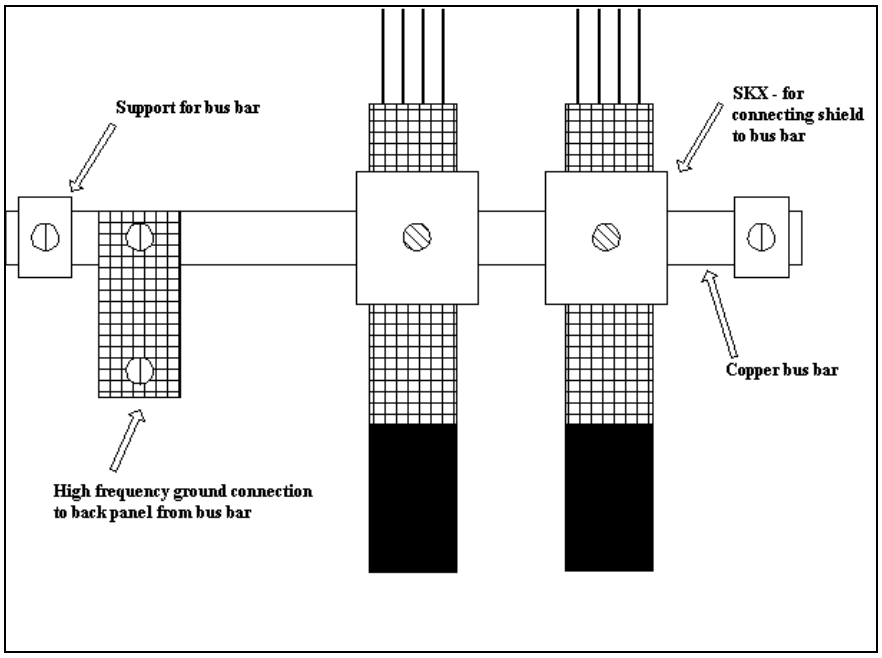
Another option is to use cable bonding clamps (offered by Phoenix Contact and others). When using the Phoenix Contact parts, make sure that a low impedance (high frequency) ground is connected from the ground bus bar to the back panel using a flat braid or a copper bus bar. The SK parts from Phoenix (SK8, SK14, & SK20) slide onto the bus bar. The cable (with exposed shield) is inserted through the SK piece and the thumbscrew on top of the SK piece is used to tighten the connection between the cable shield and the bus bar.

Phoenix Part Descriptions		
Phoenix Contact Part #	**Description**	**Cable Diameter Range**
3025163 (Type SK8)	Shielded terminal block - for placing the shield on bus bars.	SK8 (up to 8 mm or 0.315 in)
3025176 (TypeSK14)	Shielded terminal block - for placing the shield on bus bars.	SK14 (8 mm to 14 mm or 0.551 in)
3025189 (Type SK20)	Shielded terminal block - for placing the shield on bus bars.	SK20 (14 mm to 20 mm or 0.787 in)
0404428 (Type AB/SERVO**STAR**)	Support for bus bar. 2 needed to mount ground bus.	N/A
0402174 (Type NLS-CU 3/10)	Bus bar material - 10mm x 3mm copper at varying lengths.	N/A

The next two figures represent a side and top view of the SK device that clamps down on the shield of the cable. The use of the Phoenix SK device is an excellent method for providing a low impedance path between the cable shield and the back panel.


Thumb screw to tighten down shield to bus bar
cable shield compressed on copper bus bar
copper bus bar
SK(8,14,20) - Shielded terminal block

Phoenix Contact - Side View


Support for bus bar
SKX - for connecting shield to bus bar
Copper bus bar
High frequency ground connection to back panel from bus bar

Phoenix Contact -Top View

CE FILTERING TECHNIQUES

The SERVO**STAR** drive system (power supply, drive, motor) meets the CE Mark standards stated in the front of this manual. It is imperative for you to apply proper bonding and grounding techniques, described earlier in this section, when incorporating EMC noise filtering components for the purpose of meeting this standard.

Noise currents often occur in two types. The first is conducted emissions that are passed through ground loops. The quality of the system grounding scheme inversely determines the noise amplitudes in the lines. These conducted emissions are of a common-mode nature from line to neutral (or ground). The second is radiated high-frequency emissions usually capacitively coupled from line-to-line and are differential in nature.

To properly mount the filters, the enclosure should have an unpainted metallic surface. This allows for more surface area to be in contact with the filter housing and provides a lower impedance path between this housing and the back plane. The back panel, in turn, has a high frequency ground strap connection to the enclosure frame or earth ground.

INPUT POWER FILTERING

The SERVO**STAR** PD electronic system components require EMI filtering in the input power leads to meet the conducted emission requirements for the industrial environment. This filtering blocks conducted-type emissions from exiting onto the power lines and provides a barrier for EMI on the power lines.

Care must be taken to adequately size the system. The type of filter is based on the voltage and current rating of the system and whether the incoming line is single or three-phase. One input line filter is used for multi-axis control applications. These filters are mounted as close to the incoming power as possible so noise is not capacitively coupled into other signal leads and cables. Similarly, care should be taken when routing wires from the load side of the filter to the Power Supply. These lines may be noisy and should be separated from other sensitive cabling to avoid unwanted coupling of noise. Several manufacturers of these filters are listed below. They should be able to recommend the best filter design for most typical motor control applications. Danaher Motion Kollmorgen has also provided specific filters recommendations (contained in the Installation Manual) that adequately attenuate the conducted noise to levels well below the CE limits.

The implementation of the EMI filter should be done in accordance with the following guidelines:

- Filter should be mounted on the same panel as the drive and Power Supply.
- Filter should be mounted as close as possible to incoming cabinet power.
- Filter should be mounted as close as possible to Power Supply. If separation exceeds 30cm. (1 ft.), flat cable (braid) is used for the high frequency connection between filter and Power Supply.
- When mounting the filter to the panel, remove any paint or material covering. Use an unpainted metallic back panel, if possible.
- Filters are provided with an earth connection. All ground connections are tied to ground.
- Filters can produce high leakage currents. ***Filters must be earthed before connecting the supply!***
- Filters should not be touched for a period of 10 seconds after removing the supply.

MOTOR LINE FILTERING

Motor filtering may not be necessary for CE compliance of SERVOSTAR systems. However, this additional filtering increases the reliability of the system. Poor non-metallic enclosure surfaces and lengthy, unbonded (or unshielded) motor cables that couple noise line-to-line (differential) are just some of the factors that lead to the necessity of motor lead filtering.

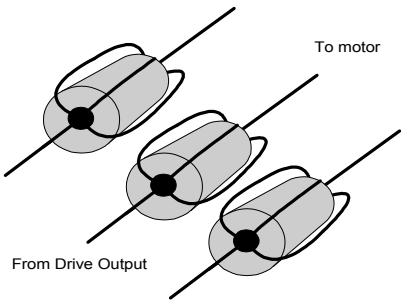
Motor lead noise may be either common-mode or differential. The common-mode conducted currents occur between each motor lead and ground (line-to-neutral). Differential radiated currents exist from one motor lead to another (line-to-line). The filtering of the lines feeding the motor provide additional attenuation of noise currents that enter surrounding cables and equipment I/O ports in close proximity.

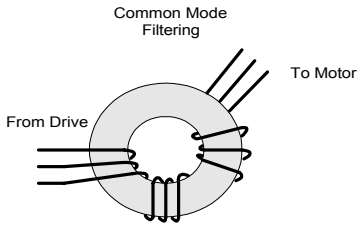
Differential mode currents commonly occur with lengthy motor cables. As the cable length increases, so does its capacitance and ability to couple noise from line-to-line. While every final system is different and every application of the product causes a slightly different emission profile, it may become necessary to use differential mode chokes to provide additional noise attenuation to minimize the radiated emissions. The use of a ferrite core placed at the drive end on each motor lead (shown in the diagram below), attenuates differential mode noise and lowers frequency (30 to 60 MHz) broadband emissions to within specifications. Danaher Motion Kollmorgen recommends a Fair-Rite P/N 264354002 (or equivalent) ferrite core.

Wrap each motor lead through the core several times as shown in the figure below:

Never wrap a ground lead through a core.

Differential Mode Filtering





Common mode currents occur from noise spikes created by the PWM switching frequency of the drive. The use of a ferrite or iron-powder core toroid, as shown in the figure above, places common mode impedance in the line between the motor and the drive. The use of a common mode choke on the motor leads may increase signal integrity of encoder outputs and associated I/O signals. The following is a list of toroidal and ferrite cores that can be used to make common mode chokes:

Toroidal Core Recommendations				
Manufacturer	**Manufacturer's Part #**	**Size**		
Micrometals	T400-26D	OD 4in (102mm)	ID 2.25in (57.2mm)	HT 1.3in (33mm)
Micrometals	ST102-267	OD 1.025 in (26mm)	ID .6 in (15.2mm)	HT .475 in (12.1mm)
Micrometals	ST150-275B	OD 1.52 in (38.6mm)	ID ..835 in (21.2mm)	HT .825 in (21mm)
Micrometals	ST200-275B	OD 2.01 in (51.1mm)	ID 1.24 in (31.5mm)	HT 1.025 in (26mm)
Magnetics	77930-A7	OD 1.09 in (27.7mm)	ID .555in (14.1mm)	HT .472in (11.99mm)
Fair-Rite	2643803802	OD 2.4in (61mm)	ID 1.4in (35.55mm)	HT .5in (12.7mm)

Pre-wound Common-Mode Chokes			
Manufacturer	**Manufacturer's Part Number**	**Danaher Motion Kollmorgen Part Number**	**Description**
Schaffner	RD7137-36-0m5	A-96843-005	500µH 3 phase common mode choke. 36 amps continuous.
Schaffner	RD8137-64-0m5	A-96843-010	500µH 3 phase common mode choke. 64 amps continuous.

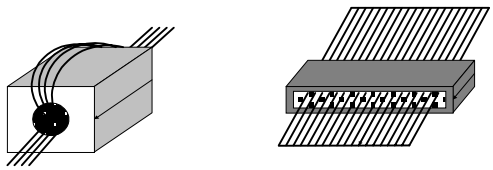
I/O FILTERING

I/O filtering may be desired, depending on system installation, application, and integration with other equipment. It may be necessary to place ferrite cores on I/O lines to avoid unwanted signals entering and disturbing the drive system or other associated equipment. The following chart lists some ferrite parts that may be used for I/O filtering and noise attenuation. These parts are ideal for providing in-line common mode impedance for I/O lines (Fair-Rite Products Corporation also has a varied selection, which suits most applications).

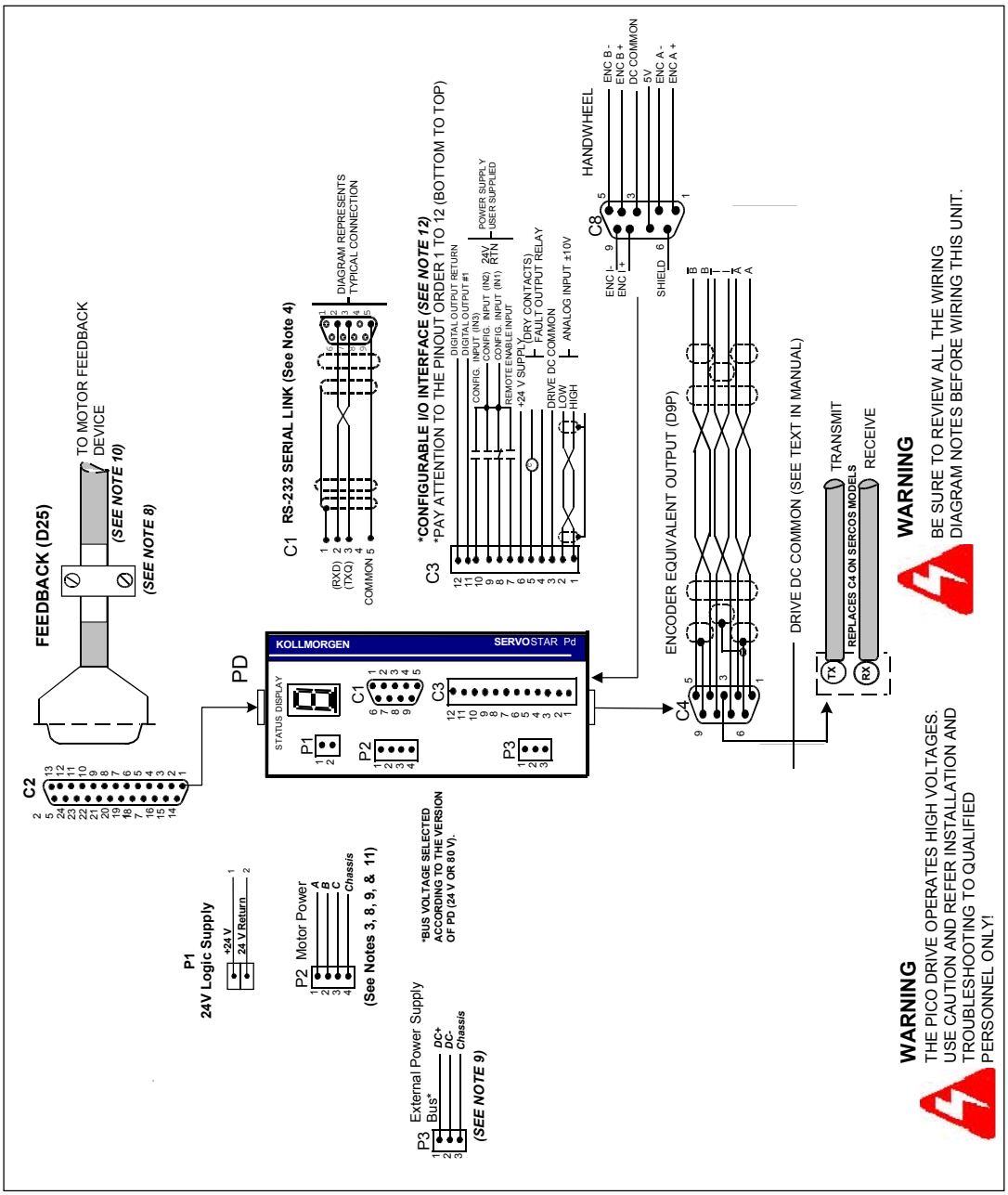
I/O Filter Recommendations			
Manufacturer	**Manufacturer's Part #**	**Danaher Motion Kollmorgen Part #**	**Description**
Ferrishield	SS33B2032	A-96770-003	Clamp on core
Ferrishield	SS33B2036	A-96769-005	Clamp on core
Ferrishield	FA28B2480	A-96771-003	Clamp on core - flat cable clamp
Ferrishield	SA28B4340	A-96772-009	Clamp on core - flat cable clamp
* Fair-Rite	2643167251		

* This core must be used with the drives for CE compliance. It should be applied to the 24 V or 80 V input power lines and the Remote Enable lines (7&8 on C3 connector) with approximately 3 turns through the core.

The following figure illustrates the use of multiple turns through a clamp-on core. The more turns created, the more impedance is added to the line. Avoid putting the shield in a clamp-on core. It is undesirable to place an impedance in-line with the shield. The use of ribbon cable may be common in many cabinets. Some ferrite clamps are designed just for ribbon cable use as shown below.



WIRING DIAGRAM



Note 1
See the Hardware Specifications for recommended line input fusing.

Note 2
Cables should be properly bonded to the back panel and implemented as close to the drive side of the cable as possible for effective grounding. If bonding is installed, the shield on the cable end need not be connected to the "star point" configuration. Only connect the shield on one end of the cable (preferably on the drive side).

Note 3
Units must be installed in an enclosure that meet the environmental IP rating of the end product (ventilation or cooling may be necessary to prevent enclosure ambient from exceeding 45°C or 113°F).

Note 4
Do not connect unused pins on C1 connector. Some manufacturers' cables connecting all the pins produce unpredictable operation.

Note 5
See the Hardware Specifications for wire gauge and ferrule sizes. All wire should be copper.

Note 6
See CE Filtering Techniques for further information.

Note 7
A flyback diode is necessary for inductive loads connected across the O1 output.

Note 8
High frequency ground between conductive back panel and enclosure. Also, a high frequency ground is required between the enclosure and earth ground.

Note 9
Bonding of motor and power cables. The use of armored (screened) motor and power cables bonded as close to the drive as possible are essential for CE compliance and strongly recommended to better the overall performance and reliability of the system.

Note 10
Feedback cable bonding is required for CE compliance. As with the motor cables, the feedback cables should be bonded to the back panel. This bonding does two things: it cuts down radiation from the drive that may be in the form of high frequency energy resulting from internal processor clocks and it provides immunity for the drive. Since the feedback device is located internal to the motor, it is going to pick up some noise currents and transmit them along the feedback cable. The bonding directs the currents from the shield of the feedback cable to back panel ground. This reduces the amount of noise entering the drive.

Note 11
Refer to Motor Line Filtering for differential mode choke information.

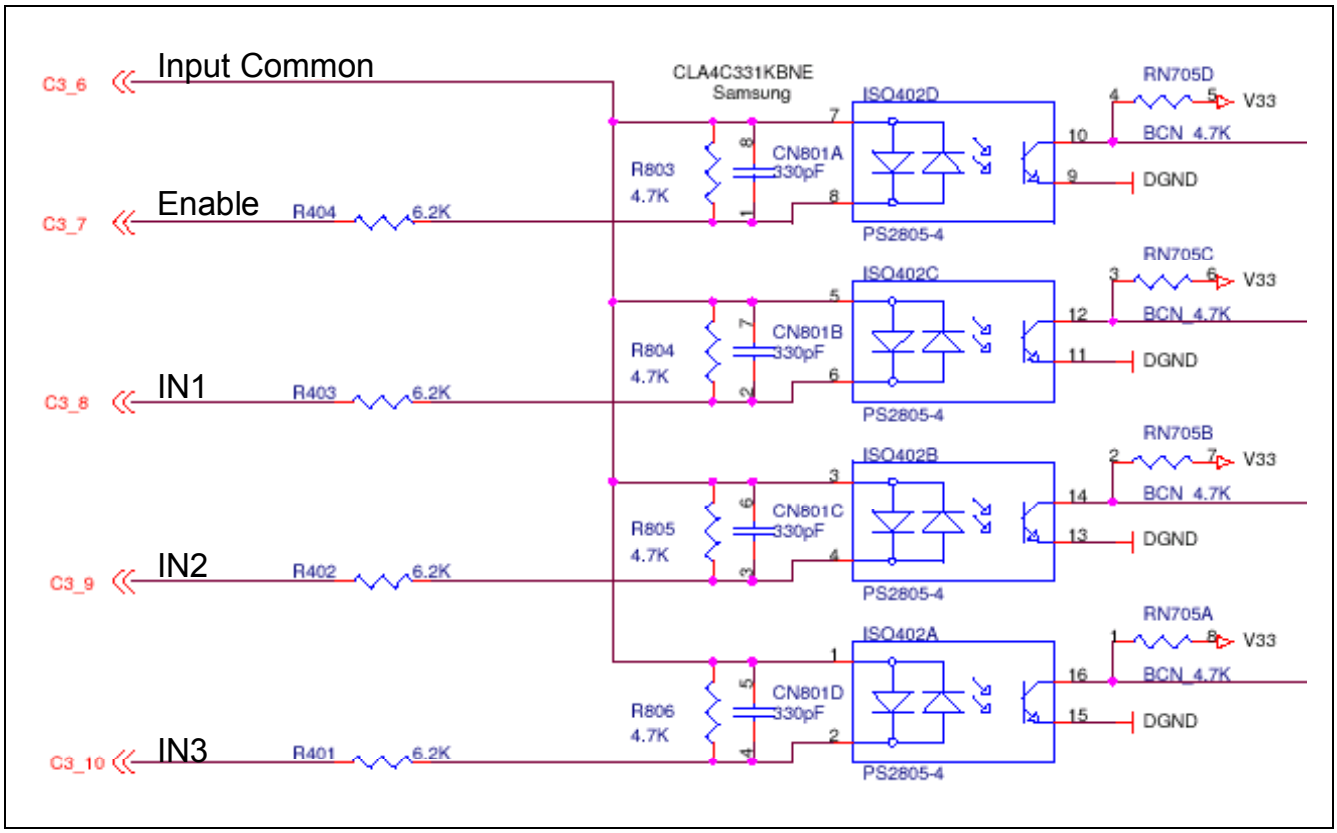
Note 12
Electro-static discharge may cause C3 to shut down. To insulate from electro-static discharge, wrap two layers of electrical tape around the body of C3.

I/O ELECTRICAL INTERFACE

The following schematic diagrams show the I/O electrical interface.

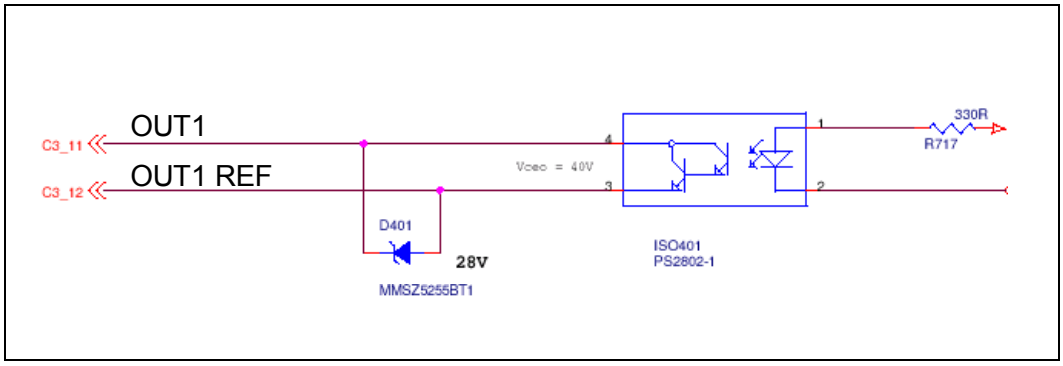
Digital Inputs and Enable

The digital inputs include the enable signal, and three general-purpose inputs (IN1, IN2 and IN3). These inputs are bi-polar, meaning the input common can be wired to either 24 V or ground. The minimum requirement to enable the drive is to connect 24 VDC between the Input Common and the Enable.

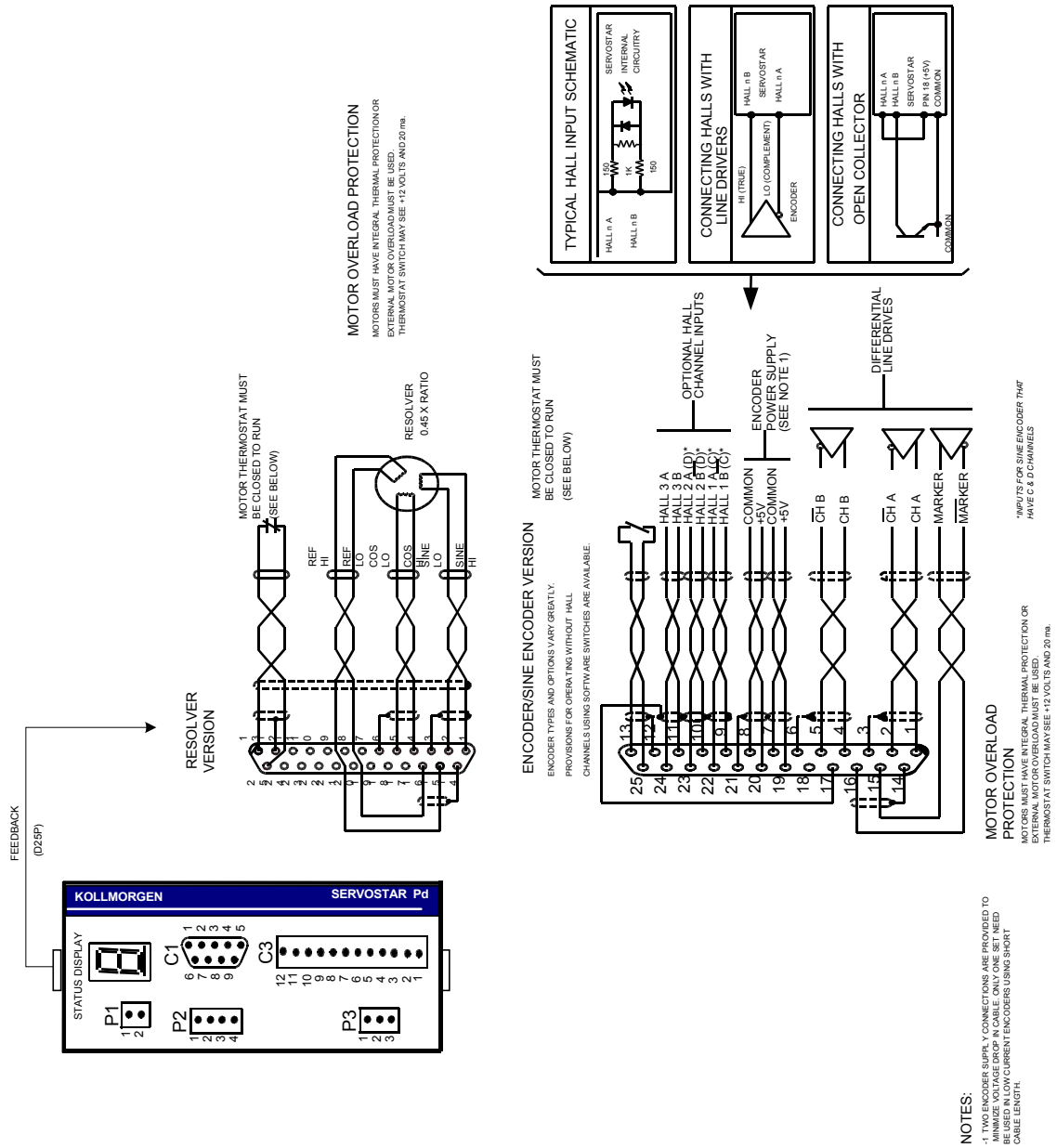


Digital Output

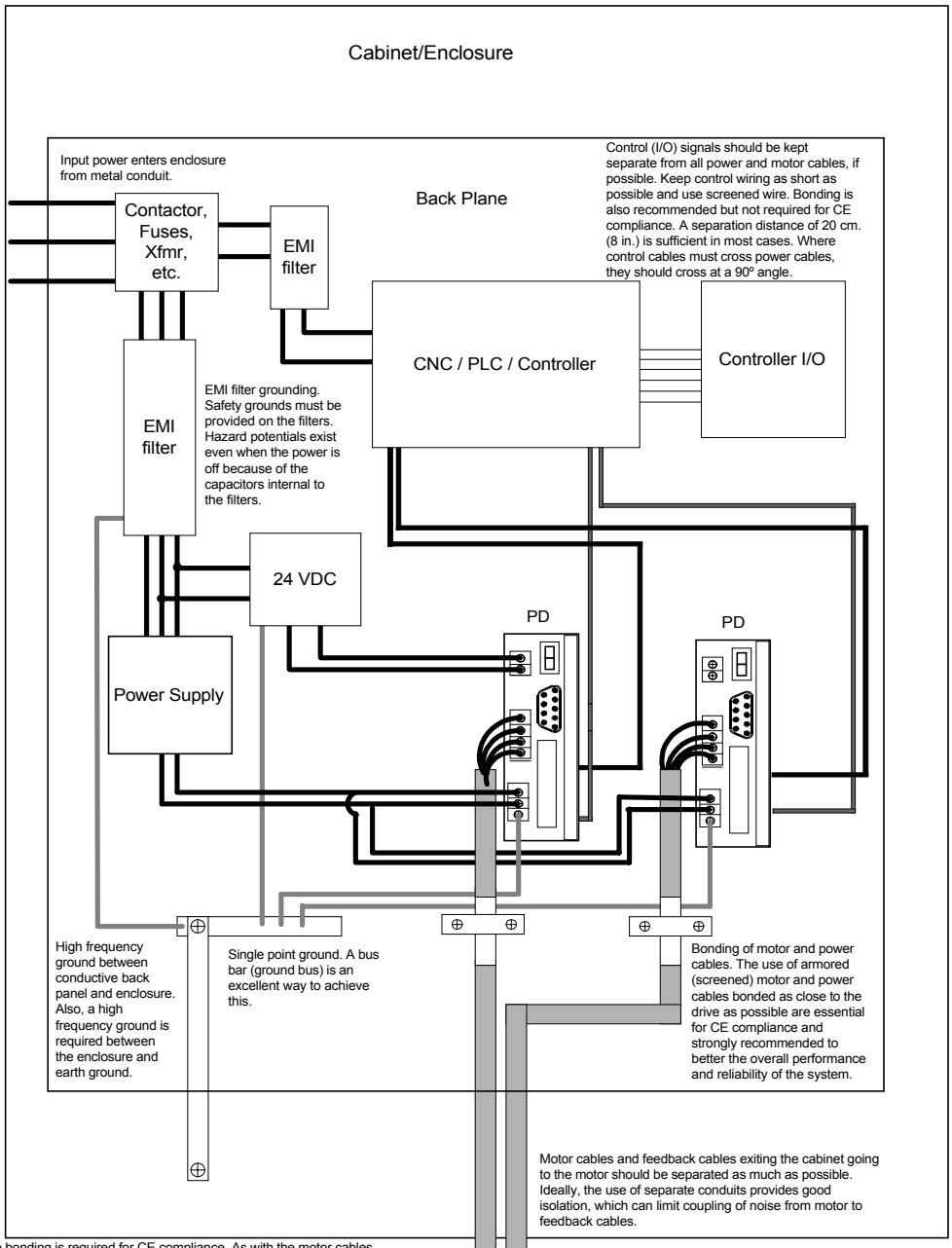
The PD has one general-purpose uni-polar digital output.



FEEDBACK DIAGRAM



FILTER AND BONDING DIAGRAM


Cabinet/Enclosure
Input power enters enclosure from metal conduit.
Back Plane
Control (I/O) signals should be kept separate from all power and motor cables, if possible. Keep control wiring as short as possible and use screened wire. Bonding is also recommended but not required for CE compliance. A separation distance of 20 cm. (8 in.) is sufficient in most cases. Where control cables must cross power cables, they should cross at a 90º angle.
Contactor, Fuses, Xfmr, etc.
EMI filter
CNC / PLC / Controller
Controller I/O
EMI filter
EMI filter grounding. Safety grounds must be provided on the filters. Hazard potentials exist even when the power is off because of the capacitors internal to the filters.
24 VDC
PD
PD
Power Supply
DC power lines that must be routed past other lines (such as motor cables or I/O lines) should cross at a 90º angle. This minimizes the coupling effect. Additionally, the power lines should be routed as close to the back panel as possible. Any noise currents on the lines are capacitively coupled to the ground plane and not to other lines.
High frequency ground between conductive back panel and enclosure. Also, a high frequency ground is required between the enclosure and earth ground.
Single point ground. A bus bar (ground bus) is an excellent way to achieve this.
Bonding of motor and power cables. The use of armored (screened) motor and power cables bonded as close to the drive as possible are essential for CE compliance and strongly recommended to better the overall performance and reliability of the system.
Motor cables and feedback cables exiting the cabinet going to the motor should be separated as much as possible. Ideally, the use of separate conduits provides good isolation, which can limit coupling of noise from motor to feedback cables.
Routed to Motors

Feedback cable bonding is required for CE compliance. As with the motor cables, the feedback cables should be bonded to the back panel. This bonding does two things: it cuts down radiation from the drive that may be in the form of high frequency energy resulting from internal processor clocks and it provides immunity for the drive. Since the feedback device is located internal to the motor, it is going to pick up some noise currents and transmit them along the feedback cable. The bonding directs the currents from the shield of the feedback cable to back panel ground. This reduces the amount of noise entering the drive.

RECOMMENDED MANUFACTURERS' LIST

Schaffner Electronik AG
Nordstrasse 11
CH-4708 Luterbach
Switzerland
Phone: 065 802 626
Fax: 065 802 641

North America
Schaffner EMC Inc.
9-B Fadem Road
Springfield, NJ 07081
Phone: 201 379-7778
Fax: 201 379-1151

Corcom

World Headquarters
844 E. Rockland Road
Livertyville, Il 60048
Phone: 708 680-7400
Fax: 708 680-8169

East Coast Sales Office
17 Sarah's Way
Fairhaven, MA 02719
Phone: 508 992-4495
Fax: 508 992-3798

West Coast Sales Office
6700 Fallbrook Ave. Suite 160
West Hills, CA 91307
Phone 818 226-4306
Fax 818 704-1757

Filter Concepts Inc.
2624 South Rouselle Street
Santa Ana, CA 92707 USA
Phone: 714 545-7003 Fax: 714 545-4607

Phoenix Contact Inc.
P.O. Box 4100
Harrisburg, PA 17111-0100
Phone 800 888-7388
Fax 717 948-3475

FerriShield Interference Control Components
Empire State Building
350 Fifth Ave., Suite 7505
New York, NY 10118-7591
Phone: 212 268-4020 Fax: 212 268-4023

Magnetics
P.O. Box 391
Butler, PA 16003-0391
Phone: 412 282-8282 (800 245-3984)
Fax: 412 282-6955

Fair-Rite Products Corp.
P.O. Box J
One Commercial Row
Wallkill, NY 12589
Phone: 914 895-2055 Fax: 914 8985-2629
E-Mail ferrites@fair-rite.com

Micrometals, Iron Powder Cores
5615 E. La Palma
Anaheim, CA 92807
Phone: 800 356-5977 Fax: 714 970-0400 Worldwide: 714 970-9400

CONNECTOR PINOUTS

PI: Logic Power Connector

Pin	Function
1	+ 24 VDC Supply Input
2	+ 24 V_RTN Supply Input

P2: Motor Power Connector

Pin	Function
1 = Ma	Motor Output Phase A
2 = Mb	Motor Output Phase B
3 = Mc	Motor Output Phase C
4	Chassis

P3: Bus Power Connector

Pin	Function
1	DC_BUS +
2	DC_BUS -
3	Chassis

C1: Serial Communications

This connector provides the RS 232 signals for serial communication between a PC and the PD. Additional signals are provided for daisy-chain connection from one PD to additional PDs.

Pin	Function
1	Shield
2	RECV (RXD) (RS232)
3	XMIT (TXD) (RS232)
4	Reserved +5V Output
5	Common
6	N/A
7	N/A
8	Daisy Chain RxD
9	Daisy Chain TxD

C2: Feedback Connector

Pin	Resolver	Encoder	Sine Encoder
1	Sine High	A	A
2	Sine Low	/A	/A
3	Shield	Shield	Shield
4	Cosine High	B	B
5	Cosine Low	/B	/B
6	Shield	Shield	Shield
7		E5V Return	E5V Return
8		E5V Return	E5V Return
9		H1B	H1B(/C) (/Data)
10		H2B	H2B(/D) (/Clock)
11		H3B	H3B
12	Shield	Shield	Shield
13	Thermostat High	Thermostat High	Thermostat High
14	Shield	Shield	Shield
15	Ref. High Out	Index	Index
16	Ref. Low Out	/Index	/Index
17	Shield	Shield	Shield
18		E5V Supply	E5V Supply
19		E5V Supply	E5V Supply
20		E5V Supply	E5V Supply
21	Shield	Shield	Shield
22		H1A	H1A (C) (Data)
23		H2A	H2A (D) (Clock)
24		H3A	H3A
25	Thermostat Low	Thermostat Low	Thermostat Low

C3: User I/O Connector

Pin	Function
1	Analog Differential Input + (High)
2	Analog Differential Input - (Low)
3	DC Common
4	Fault Output Relay Contact
5	Fault Output Relay Contact
6	+24V Input Common Rail for Enable, CW, and CCW Inputs
7	Remote Enable Input
8	CW End Travel Limit Input (IN1)
9	CCW End Travel Limit Input (IN2)
10	IN3 (Digital Input #3)
11	OUT1 (Digital Output #1)
12	OUT1_REF (Digital output return)

C4: Equivalent Encoder Output

Pin	Function
1	Encoder Channel A Output + (High)
2	Encoder Channel A Output - (Low)
3	DC Common
4	Encoder Channel B Output + (High)
5	Encoder Channel B Output - (Low)
6	Shield Connection
7	Encoder Marker (or Index) Channel Output + (High)
8	Encoder Marker (or Index) Channel Output - (Low)
9	Shield Connection

C8: Handwheel / Secondary Encoder

Pin	Function
1	Encoder Channel A Input + (High)
2	Encoder Channel A Input - (Low)
3	DC Common
4	Encoder Channel B Input + (High)
5	Encoder Channel B Input - (Low)
6	Shield Connection
7	Encoder 5 V Supply
8	Encoder Channel I Input +
9	Encoder Channel I Input -

FEEDBACK DEVICES

RESOLVER

The SERVO**STAR** uses either single (two poles) or multi-speed (multiple poles) resolver feedback to monitor the motor shaft position. A resolver can be thought of as a transformer whose output is unique for any given shaft position (an absolute position feedback). The transformer is driven with a sinewave reference signal. Two AC signals are returned from the resolver into the Sine and Cosine inputs. All three of these sinewave signals are low-level and susceptible to noise.

Specifications

Resolver Requirements	
Type	Control Transmitter
Transformation Ratio	0.47
Modulation Frequency	7-8 kHz
Input Voltage (From Drive)	4.25 VAC
Max DC Resistance	120 Ohms (stator)
Max Drive Current	55 mA AC-RMS
Output Voltage (To Drive)	2 VAC

Cable Lengths

It is important to use properly- shielded cable and to keep it away from other noise-radiating devices and cables. It is not recommended to run the feedback and motor cables in the same conduit. Danaher Motion Kollmorgen has tested cable lengths up to 75 ft. (22 9 m.). without degradation of performance. However, performance may vary, depending on motor and resolver type. Tests were performed with standard Danaher Motion Kollmorgen cable and its low-impedance and Danaher Motion Kollmorgen **GOLD**LINE motor resolver. Please consult the factory for cable and resolver impedance specifications when long cable runs above 250 ft. (76 m.) are desired. Danaher Motion Kollmorgen recommends twisted-shielded pair for feedback cables.

Resolution and Accuracy

The SERVO**STAR** calculates motor velocity as the derivative of position (change in position over time). With its patented technique, all readings are extended to a resolution of 16-bit. For velocity feedback calculations, the drive converts the resolver input to 18-bits of resolution, giving smooth motor velocity control. The digital resolution (RDRES) of the Resolver-to-Digital Converter system is determined automatically according to the application velocity limit (VLIM). The following is a summary of the SERVO**STAR**'s resolution capabilities:

R/D Converter Specifications			
VLIM (RPM)	**RDRES**	**Counts/Rev**	**Encoder Eqv. Output (C4)**
> 6100	12	4096	4096 quad counts
1500 to 6100	14	16384	16384 quad counts
< 1500	16	65536	65536 quad counts

System accuracy using resolver feedback is effected by several components. The following table gives information on the inaccuracy that each of these components contribute to the total accuracy of a standard SERVO**STAR** system:

Resolver Accuracy Specifications	
Components	**ArcMinutes**
R/D Converter	4
Resolver mechanics (rotational)	8
Resolver mounting on motor shaft	2
Inter-LSB (digital dither over the least significant bit)	5
Total (Worse-case)	**19**

DIGITAL ENCODER

The SERVO**STAR** can use encoder feedback to monitor the motor shaft position. As opposed to a resolver, which is an absolute position feedback device, the encoder is an incremental device that indicates changes in position. The encoder resolution of the SERVO**STAR** (and therefore the drive's encoder equivalent output) is fixed because it is a hardware characteristic of the encoder device. The encoder interface includes three groups of wires:

1. A/B (and complements) lines make up the encoder quadrature signals. The signals are received differentially through line receivers before being passed through a wire-break detection circuit.
2. The narrow Index pulse normally appears once per revolution and indicates a known physical position of the shaft. This pulse is received differentially through a line receiver before being passed through a wire-break detection circuit. This signal is hardware-capturable.
3. Hall signals provide information representing the approximate absolute location of the motor shaft. From this information, the motor can sinusoidally commutate forward until the index signal is detected - at which time, true position is known. These signals are isolated by an opto-coupler and can be differential or open-collector type signals.

Specifications

Encoder Requirements	
Required Signals	Types: A, B with or without Index pulse A, B, Index with or without Hall Channels * Halls may be integral or discrete
Signal Type: A-quad-B and Marker Halls	Differential: do not connect single-ended Differential or Open Collector
System Voltage	5 VDC
Maximum Input Frequency	From encoder: 3 MHz (before quad), 12 MHz (after quad)
Maximum Cable Length	System Dependent: 50 ft. (15m.) Recommended
Maximum Line Count Per Motor Electrical Cycle	10,000,000
Maximum Supply Current from SERVO**STAR**	250 mA
Protection	Separate Voltage Regulator, Broken wire detector for A, B, Index, and Hall channels, Illegal Hall Code Detection

Cable Lengths

The recommended cable length when using the SERVO**STAR** to source the encoder is no longer than 50 ft. (15 m.). Long encoder cables tend to have high DC resistance that may create significant loading effects in the supply lines to the encoder. Please consider this carefully when designing the system. An option that would allow the use of longer lengths, implements a separate supply located at the motor to source the encoder. Quadrature signals returned to the drive are differentially connected which normally do not constitute a problem with longer cable lengths.

Resolution and Accuracy

A SERVO**STAR** encoder-based system typically exhibits minimal inaccuracies outside of the encoder itself. To get an approximate total value the customer need only look to the specifications listed for the encoder being used.

SINE ENCODER

The SERVO**STAR** can receive an analog (or sine) encoder feedback device to monitor the motor shaft position. As opposed to a digital encoder, which generates incremental square-wave signals, a sine encoder outputs analog differential sinusoidal signals. These sine signals are quadrature-decoded and passed to an interpolation circuit that breaks each 360° cycle into 256 parts before passing it to the drive's control board. Thus, the resolution seen by the drive is 256 times the fundamental sinusoidal track on the motor's encoder. The advantage of this approach is the ability to obtain much high encoder resolution while maintaining a relatively low input frequency through the cable and into the SERVO**STAR**. The encoder interface includes three groups of wires:

1. A/B (and complements) lines make up the encoder quadrature signals. The signals are received differentially at 1 V peak-to-peak amplitudes before being processed by the interpolation circuitry.
2. The narrow Index pulse normally appears once per mechanical revolution and indicates a known physical position of the shaft. This pulse is received differentially through an op amp before being squared up and sent to the control board.
3. Upon power up, commutation signals are used to communicate coarse position information. The first three signal types give approximate position information so the drive can commutate the motor forward until the Index pulse is found (There are situations where the index signal is not available. Course position information is used to commutate the motor indefinitely). The fourth gives absolute information bypassing the need for the Index signal. They are:
   - No Hall signals exist if no power-up commutation signals are available. The SERVO**STAR** can excite two phases and lock the shaft in place. It then approximates position of the locked shaft and uses only the incremental signals to commutate forward until the index is found.
   - Hall signals provide information representing the approximate location of the motor shaft (6 transitions per electrical cycle of the motor). From this information, the motor can six-step commutate forward until the index signal is detected - at which time true position is known and sinusoidal commutation begins. These signals are isolated by an opto-coupler and can be differential or open-collector type signals.
   - C/D lines are an alternative to Hall signals. These lines provide a SIN/COS sinusoidal signal where one electrical cycle equals one mechanical revolution (identical to single-speed resolver feedback). Interpolation is performed on these signals: thus, absolute position is known within 256 parts of a mechanical revolution. The motor can commutate forward until the Index signal is detected.
   - Sine encoders with Endat capability add another approach to communicating commutation position. Here, absolute position information is stored in the encoder and is serially communicated to the drive upon power up. The data is received synchronously by a clock signal provided by the drive. Absolute position is known immediately; therefore, an index signal is not needed.
   - Sine encoders with Hiperface capability are similar to EnDat, but the data is transmitted asynchronously.

Specifications

Sine Encoder Requirements	
Required Signals	Types: A, B with or without Index A, B, Index with discrete Hall Channels A, B, Index with C, D once per revolution A, B, Endat
Signal Level:	1V peak-to-peak
Signal Type: A, B, Index C, D Endat (Data/Clock) Halls	Differential Differential Differential Differential or Open Collector
System Voltage	5 VDC
Maximum Input Frequency	From encoder: 125 kHz line, 500 kHz quad After Internal Drive Interpolation: 31.25 MHz line, 125 MHz quad
Maximum Cable Length	System Dependent: 50 ft. (15 m.)Recommended
Maximum Line Count per Motor Electrical Cycle	39,000 Line counts 10,000,000 Line counts after internal drive interpolation
Maximum Supply Current from the SERVO**STAR** for encoders	250 mA
Protection	Separate Voltage Regulator, Broken wire detector for A, B, Index, and Hall channels, Illegal Hall Code Detection, A/B signals out of range, ”burst” pulse overflow
Maximum Drive Internal Interpolation (input)	x256 (before quad)

Cable Lengths

The recommended cable length when using the SERVO**STAR** to source the encoder is no longer than 50 ft. (15 m.) Long encoder cables tend to have high DC resistance that may create significant loading affects in the supply lines to the encoder. Consider this carefully when designing the system. An option that would allow the use of longer lengths would be to put a separate supply at the motor to source the encoder. Except for noise susceptibility, signals returned to the drive are differentially connected which normally do not constitute a problem with longer cable lengths.

Resolution and Accuracy

Internal resolution of the system can be derived through the following calculation:

Encoder line resolution x 256 x 4 (quadrature).

System accuracy is largely dependent upon the accuracy of the encoder itself. To get an approximate total value, the customer need only look to the specifications listed for the encoder being used.

ENCODER EQUIVALENT OUTPUT

The SERVO**STAR** provides a motor position output to you in the form of quadrature encoder signals eliminating the need for an additional position feedback device. The outputs are differential line drivers. There is an associated DC common output (C4: pin 3) which can connect to your port to keep common mode noise and voltage spikes minimized for device protection. Because there are normally differences of potential between your controller and the drive, connection is recommended (if ground loops occur, disconnect and retest). The source of the Encoder Equivalent Output (EEO) signals depends on the type of motor feedback device:

Resolver Systems

The output signal is developed through the R/D hardware circuitry for minimal phase lag and has a maximum frequency determined by the motor speed and R/D limits. It provides a configurable (ENCOUT) resolution of up to 16384 lines (65536 quad counts) per revolution of the motor shaft. The placement of the index pulse (INDEXPOS) can be varied on resolver systems within 360 electrical degrees of the feedback signal. For single-speed resolvers, this means you can vary the position of this signal over one mechanical revolution. For multi-speed resolvers, the mechanical position variation is determined by the pole-pair count of the resolver (e.g. three-speed resolver gives mechanical variation of the pulse within 1/3 of a revolution).

Encoder Systems

The output signal is the actual encoder feedback signal that is pre-configured (MENCRES) in the drive's motor parameters. It can be scaled down by multiples of two (ENCOUTO: 1, 2, 4, 8, 16) and has a maximum frequency limit of 3 MHz.

Sine-Encoder Systems

This output signal is developed for a resolution that is determined by a divisor (SININTOUT: 128, 64, 32, 16, 8, 4, 2, 1) of the actual sine-encoder line resolution (MENCRES). It is then encoded to a quadrature signal before being exported out of the drive. The maximum frequency limit is 1.2 MHz. A frequency limiter (MSINFRQ) is provided with burst frequency fault protection.

EEO Phasing

The EEO signals are not phased the same for resolver and encoder systems. The following demonstrates these phasing relationships:

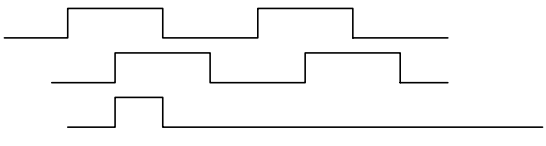
Resolver Systems

A-Leads-B convention for clockwise rotation:

Channel A

Channel B

Index (AB high)



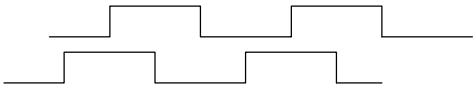
Encoder and Sine-Encoder Systems

B-Leads-A convention for clockwise rotation

Channel A

Channel B

Index (determined by encoder)



DIP SWITCH CONFIGURATION

DIP SWITCH DESCRIPTION

The 10-position DIP switch is for setting the drive address and for certain drive configuration. This switch provides the following functions:

Switch #	Function	Settings
1	Addressing	Bit 0 of Address (LSB)
2		Bit 1 of Address
3		Bit 2 of Address
4		Bit 3 of Address
5		Bit 4 of Address (MSB)
6	Baud Rate	Serial Mode 0 = 9600 1 = 19200 SERCOS interface Mode 0 = 2 Mb 1 = 4 Mb
7	HOLD Mode Switch	0 = Hold Mode Inactive 1 = Hold Mode Active
8	Drive Enable / Disable	0 = Drive Enable 1 = Drive Disable
9	SERCOS Transmit Power	0 = Low Power 1 = High Power
10	Factory Reserved	Must Be set to 0

Address Select: Switches 1 through 5 set the drive's address. A drive having address 0 powers up in the non addressed state. If these five switches are set to anything but 0, the drive assumes an address code indicated by the switch settings. The address switches are read only at power up.

Baud Rate: Switch 6 sets the baud rate to either 9600 bps (switch off) or 19200 bps (switch on) in the serial mode. In the SERCOS interface mode the baud rate can be set to either 2 M bps (switch off) or 4 M bps (switch on).

Position Hold: Activating switch 7 causes the drive to enter a position hold mode. The condition is signaled by a flashing status display. The display maintains its current OPMODE code. If the drive is running during a HOLD command detection, the motor ramps to a stop at the DECSTOP rate.

Enable: Switch 8 is an input to the drive enable circuitry and is used to force the drive to a disabled state.

SERCOS interface Power Level: Functions only on SERCOS interface products. If switch 9 is set to 0, the SERCOS transmitter uses a low power setting so it does not overdrive the receiver when using short cables. Long cables require more power.

Factory Reserved: Must be set to 0.

DRIVE ADDRESS DIP SWITCH SETTINGS

The following table shows the DIP switch address settings.

Drive Address	Switch 5	Switch 4	Switch3	Switch 2	Switch 1
0	Off	Off	Off	Off	Off
1	Off	Off	Off	Off	On
2	Off	Off	Off	On	Off
3	Off	Off	Off	On	On
4	Off	Off	On	Off	Off
5	Off	Off	On	Off	On
6	Off	Off	On	On	Off
7	Off	Off	On	On	On
8	Off	On	Off	Off	Off
9	Off	On	Off	Off	On
A	Off	On	Off	On	Off
B	Off	On	Off	On	On
C	Off	On	On	Off	Off
D	Off	On	On	Off	On
E	Off	On	On	On	Off
F	Off	On	On	On	On
G	On	Off	Off	Off	Off
H	On	Off	Off	Off	On
I	On	Off	Off	On	Off
J	On	Off	Off	On	On
K	On	Off	On	Off	Off
L	On	Off	On	Off	On
M	On	Off	On	On	Off
N	On	Off	On	On	On
O	On	On	Off	Off	Off
P	On	On	Off	Off	On
Q	On	On	Off	On	Off
R	On	On	Off	On	On
S	On	On	On	Off	Off
T	On	On	On	Off	On
U	On	On	On	On	Off
V	On	On	On	On	On

SYSTEM COMMUNICATION

You communicate with the SERVO**STAR** PD through either the serial port RS-232 or on a SERCOS interface fiber-optic ring (SERCOS interface versions only). The serial port can communicate at baud rates of 9600 or 19200 bits per second (DIP switch 6) in RS-232 configuration.

The SERVO**STAR** PD comes with its own software interface called **MOTIONLINK**®. **MOTIONLINK** is a Windows-based program designed to effectively assist you in setting up and controlling the drive's operation. It is highly intuitive in nature and contains an extensive context-sensitive on-line Help (F1) tool. The on-line Help describes how to use the program in detail and serves as a valuable reference for the drive's variable and command set, setup process, and troubleshooting techniques. You can download **MOTIONLINK** from the website (www.danahermotion.com).

Also available is the *VarCom Reference Guide* detailing the complete variable and command set. This guide is a great added resource to **MOTIONLINK** when using the package in the Terminal mode of operation.

Since the software is designed to guide you through the operation process of the drive, the **MOTIONLINK** discussion in this section covers only general steps of use. A "dumb terminal" can also be used to communicate to the drive. You will find this method of communication very awkward until a certain level of familiarity with the drive's operation is achieved. **MOTIONLINK** also provides a terminal emulation feature that contains many useful editing tools for this type of communication.

COMPUTER REQUIREMENTS

MOTIONLINK requires an IBM-PC or compatible computer with the following features:

1. IBM-PC, XT, AT, 386, 486, PS/2, or compatible computer.
2. 16 MB RAM.
3. Windows , Windows98, or Windows NT 4.0 with Service Pack 3
4. CD-ROM player
5. Standard Video Adapter (CGA, MDA, EGA, MCGA, and VGA).
6. Serial Port (for communication link with SERVO**STAR**). The serial communications port may be COM1, COM2, COM3, or COM4. COM1 is the normal configuration:

   COM1: Address 3F8h, Interrupt Request #4
   COM2: Address 2F8h, Interrupt Request #3
   COM3: Address 3E8h, Interrupt Request #4
   COM4: Address 2E8h, Interrupt Request #3

DRIVE COMMUNICATION

Review and be familiar with this section completely before applying power to the system.

Some drives are shipped from the factory already configured for a particular motor. You can verify this by applying logic power and monitoring the Status Display. A factory-configured drive goes through a power-up sequence flashing all segments of the display before settling out to a number indicating the mode of operation. If the drive is not configured with a particular motor, the display flashes a minus sign "-" indicating that you must enter drive, motor, and application variable parameters. The remainder of this section describes the process of setting up a non-configured drive.

Caution must be taken when applying power to the drive. It is factory configured to enable upon application of power. Verify that the hardware Remote Enable (REMOTE) enable switch is disabled.

RS-232-A Connection

When communicating with the drive over RS-232, the each drive's address must be unique and set to a non-zero value (using the first 5 DIP switches). The drive's communication protocol requires that the drive be "addressed" by software before it will respond. **MOTIONLINK** automatically detects the drive's address. When working through a terminal, enter the instruction in order to address the drive:

\x

where 'x' is the drive's address. When one drive is addressed, all other drives are unaddressed and ignore the instructions being transmitted over the bus.

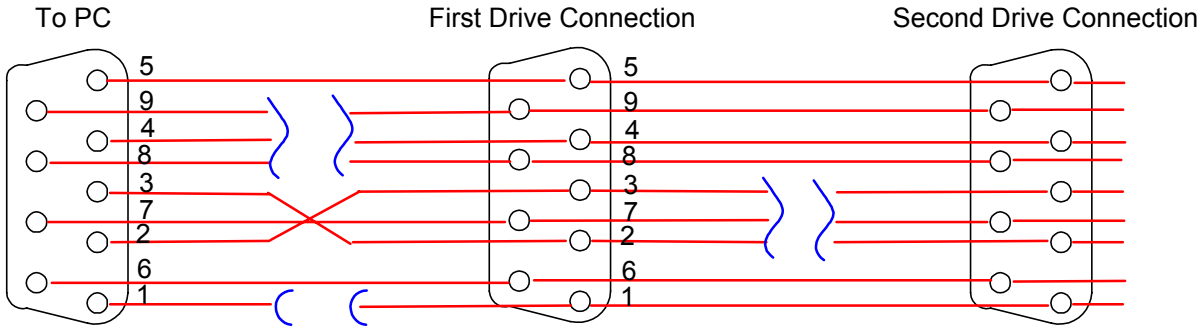
RS-232 Daisy-Chain

The SERVO**STAR** PD has RS-232 Daisy-Chain support built into the communications port. The Daisy-Chain mechanism implements a communications bus that allows multiple drives to be connected together from a single PC.

Since the RS-232 communications between the drive and the host PC uses only three wires (Transmit, Receive, Ground) and the connector has 9 pins, the spare pins are utilized for the Daisy-Chain communication. A ribbon cable can be used to connect the PC and the drive, but care must be taken to cut some of the wires in the cable.

The indicated cable wires MUST be cut to avoid damaging either the PC or the SERVOSTAR PD.

The diagram below shows the connection from the PC to the first drive, and from the first drive to subsequent drives.

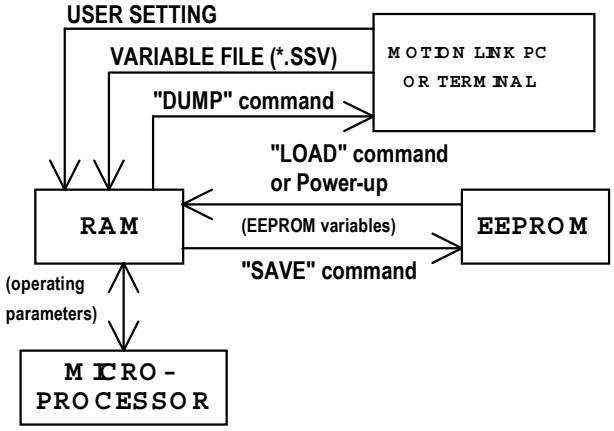


To connect the PC to the first drive, only pins 2, 3, and 5 on the PC are required. Pins 6 and 7 are optional and do not effect operation.

To connect between the drives, only pins 5, 8, and 9 are required. The rest are optional and do not effect operation.

Sending/Retrieving System Data

The following chart describes the flow of data between the PC and the SERVO**STAR**. When logic power is applied to the drive, it loads the variable parameters stored in EEPROM into the dynamic RAM for fast and easy access. You can read (and write) these variable parameters to (and from) the PC by one of several methods described in the INITIAL STARTUP section.



The PC transmits serial data to the drive and stores it in dynamic RAM. However, any variable data changed from the PC is lost when logic power is lost, if it is not saved into non-volatile EEPROM. Each variable listed in the *VarCom Reference Guide* indicates whether it can be saved to the EEPROM.

If you are configuring the same system on similar applications, the variables can be saved on disk in an .SSV file for convenient downloading into other drives.

INSTALLING MOTIONLINK

1. Download **MOTIONLINK** from either the Product Support Package CD-ROM or from the website (www.motionvillage.com/products/software_downloads/**MOTIONLINK**/).
2. Select the version of **MOTIONLINK** for the SERVO**STAR** PD and follow the instructions on the screen.

RUNNING THE PROGRAM

Go to your Start/Programs listing and select SERVO**STAR MOTIONLINK** from the menu (or click on the SERVO**STAR MOTIONLINK** icon if loaded on the desktop).

USING MOTIONLINK

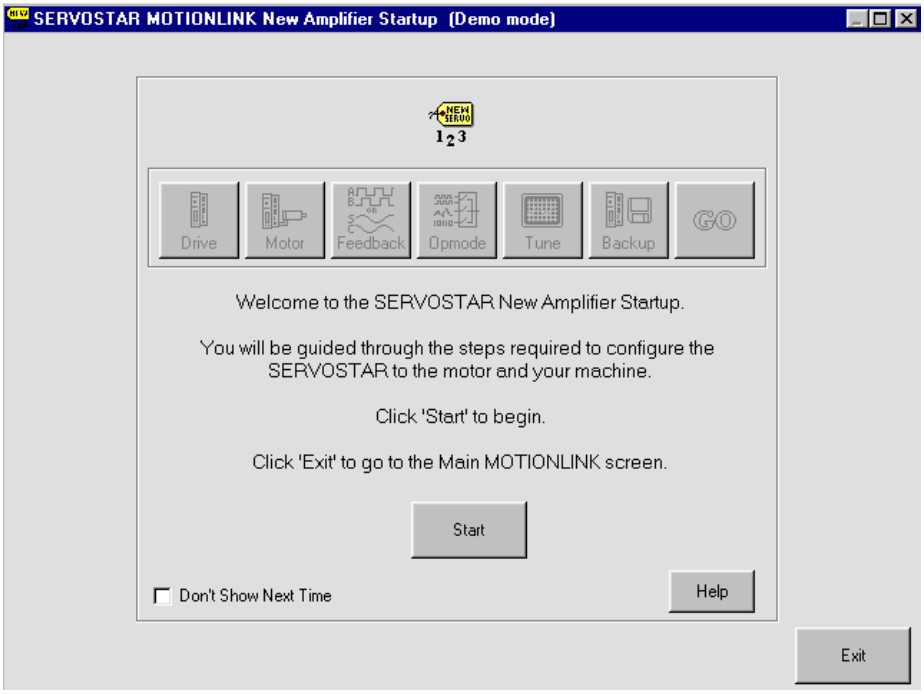
MOTIONLINK gives you three methods to configure the drive. The first uses the Startup screen and is the easiest and most highly recommended approach. Its main purpose is for initial startups.

The second approach allows you to more indirectly perform the same configuration as the first using the Main **MOTIONLINK** screen. This method is most convenient when corrections to an existing configuration is needed.

The third method uses the Terminal Mode screen to directly set (or monitor) values for the same variables and commands that the other two methods configure through a more friendly user interface.

You can gain a more thorough understanding of the SERVO**STAR** PD, **MOTIONLINK**, and its variable and command set by using the context-sensitive Help (F1) provided in **MOTIONLINK**.

MOTIONLINK Startup Wizard



The **MOTIONLINK** Startup Wizard screen appears the first time (and any time after should you leave it selected) **MOTIONLINK** is run on a PC. It is designed to guide you through a step-by-step approach to configure a drive. Click the "START" button on the first user screen and walk through the complete sequence of buttons provided to set the drive, motor, and application (Opmode, Tune, Backup, Go) variable parameters.

Should you de-activate this screen, it can be reactivated by going to the Main MOTIONLINK screen, pulling down the Configuration menu and selecting the New Drive (123) option.

1. **Setting Drive Variable Parameters**: Click the Drive button. This screen allows you to select a BUS value that corresponds to the incoming line voltage. This selection actually determines the setting of the variable VBUS. Also included is a realtime monitoring of the DIP switch on top of the drive so you can verify the proper setting for the drive address, baud rate, and various other parameters. Click Exit to return to the Startup screen.
2. **Setting Motor Variable Parameters**: Click the Motor button. This screen allows you to access the **MOTIONLINK** motor database. Select a motor family and then a model within that family. Information will appear in the blank parameter fields on the right. Click on the "To Drive" button beneath the fields to send the variable parameters to the drive. Click "Exit" to return to the **MOTIONLINK** Start-Up Wizard.

If you have a configured drive, a "From Drive" button is provided to retrieve the motor data already in the drive. Retrieving this data does not erase it from the drive.

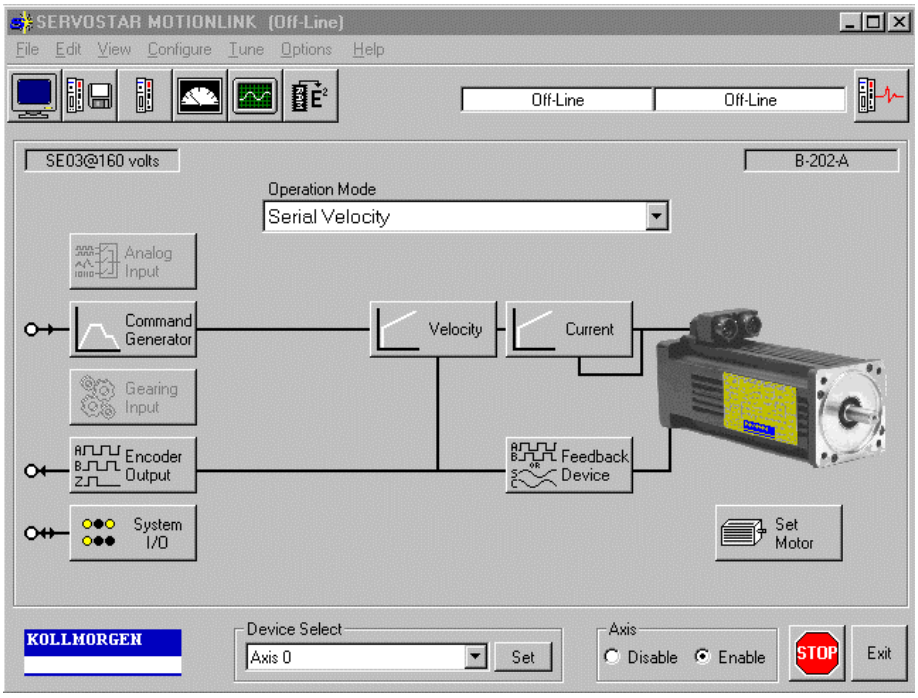
If the motor cannot be found in the database, contact the Danaher Motion Customer Support for detailed instructions.

3. **Customizing to Application**: Click the "Opmode" button in the Startup screen to select the mode of loop control desired; position, velocity, or torque. Click Exit to return to the **MOTIONLINK** Start-Up Wizard.
4. **Tune the drive**: Click on the Tune button in the **MOTIONLINK** Start-Up Wizard to set the system bandwidth, the type of loop control, and the filtering necessary for the application.

Caution should be used when executing the AutoTune feature. Some applications are not capable of handling the vibration caused as the shaft senses its load. If this is in question, manually tune the drive. Also, when the load inertia is very large and the selected bandwidth is high, this feature may fail to perform.

5. **Setup Completion**: Click EXIT to go to the Main **MOTIONLINK** screen.

Main MOTIONLINK Screen



This screen appears the when you exit out of the Startup screen. All the screens mentioned in the method above can be accessed from this screen and should be used to make corrections in the current system configuration.

1. **Setting Drive Variable Parameters**: From the Configure menu, click the Drive option. The same screen appears as described in the Startup screen section. Click Exit to return to Main **MOTIONLINK** Screen.
2. **Setting Motor Variable Parameters**: selecting the Motor option under the Configure menu, you can obtain the same parameter screen found in the Startup screen. Click Exit to return to Main **MOTIONLINK** Screen.
3. **Customizing to Application**: By dropping down the Operational Mode listing, you can select the mode of loop control desired (position, velocity, torque). Clicking the "Tune" button, you can select the system bandwidth, the type of loop control, and the filtering necessary for the application. These are the same parameter screens found in the Startup screen. Click Exit to return to Main **MOTIONLINK** Screen.
4. **Saving Variable Parameters to EEPROM**: At the top of this screen, you can click the button labeled "RAM/E^2 " to save the modified variables from RAM to EEPROM.

5. **Saving Variable Parameters to .SSV file**: Occasionally, you may wish to backup the variable parameters from one drive for use in another. To do this, pull down the Edit menu and select Backup Variables, request the information from the drive ("Receive" button) into the editor, and save ("Save" button) the contents in a .SSV format to a specified disk location.
6. **Restoring Factory Variable Parameters**: To restore the original factory variable parameters, pull down the Configure menu, select Motor, and select the motor family and motor model. Click the "To Drive" button to send the variable parameters to RAM and the "RAM/E^2 SAVE" button to save to EEPROM.
7. **Restoring Custom Variable Parameters**: This process assumes that you saved the custom variable parameters to a .SSV file, as described above. To restore the custom parameters, pull down the Edit menu, select Backup Variables, and click on "Open". Highlight the custom .SSV file to import variable parameters into editor. Click "Xmit" to send variable parameters to drive.

Terminal Mode

Use the **MOTIONLINK** Terminal Mode (or any other "dumb" host) to directly monitor or modify the variable set and command the drive. This approach should only be taken when a PC with a Windows operating system is not available or you are well-versed with the SERVO**STAR** PD variable and command set.

The *VarCom Reference Guide* contains the complete variable and command set. Each variable or command must be referenced for its syntax and parameter definition. The variables and commands are grouped by function for terminal users.

1. **Clear EEPROM**: If a "-" does not appear and you wishe to enter a new set of variable parameters, type CLREEPROM at the terminal prompt to clear the EEPROM memory.
2. **Setting Drive Variable Parameters**: At the prompt, enter a value for VBUS. Other drive parameters are determined automatically.
3. **Setting Motor Variable Parameters**: Locate the motor parameter group of variables in the *VarCom Reference Guide*. At the prompt, enter values for the variable parameters listed in this group by typing the name of the variable, space, and the numerical value.
4. **Customizing to Application**:
   Locate the following variable groups in the *VarCom Reference Guide*:
   A. Analog Input-Related
   B. Current Parameters
   C. Velocity Parameters
   D. Position Parameters
   E. Loop Compensation and Gains Parameters
   F. Motion Control Parameters

   At the prompt, enter values for the variable parameters listed in these groups by typing the name of the variable, space, and the numerical value. You are strongly encouraged to develop a full understanding of these variables before finalizing the configuration.
5. **Saving Variable Parameters to EEPROM**: At the prompt, type SAVE. This will save the variable parameters stored in the RAM to the EEPROM. All of the variables listed in the VarCom Reference Guide indicate whether its contents can be saved to EEPROM.
6. **Saving Variable Parameters to .SSV file**: At the prompt, type DUMP. The DUMP command causes the drive to output variables and their contents to the serial port in the format of a variable file (this includes the trailing CONFIG command). This variable file format is an ASCII file consisting of a series of variable assignment statements. The resulting transmission of data from the drive can then be saved with a .SSV extension.

7. **Restoring Factory Variable Parameters**: If you have not saved any changes stored in RAM to EEPROM, type LOAD at the prompt and the original parameters will be loaded from the EEPROM into RAM. If changes have already been previously saved, contact the factory to obtain a set of motor variable parameters for the motor specified in the model number. At the prompt, re-enter all the motor variable parameters. Type the CONFIG command followed by the RSTVAR command.
8. **Restoring Custom Variable Parameters**: At the prompt, type RSTVAR. Transmit to the drive the custom variable .SSV file. The contents of this file should have the CONFIG command as its last statement. The drive executes this command and configures itself to the parameters that were transmitted.

POWER-UP SEQUENCE

Upon powering up, the SERVO**STAR** PD performs a series of self-tests. If the Status Display illuminates a solid number, no errors were found and the EEPROM has loaded its variable parameters (or loaded with default values in case of invalid EEPROM data) into RAM. The Remote Enable switch on the I/O connector (C3) may now be energized, thus enabling the servo loops.

ENABLING THE SYSTEM

The drive enable logic is based on the following variable switches and flags:

ACTIVE: This is the overall readiness flag indicating the enable/disable state of the drive. If high (1), the drive is enabled and power is being applied to motor. The following equation must hold true for ACTIVE to go high:

ACTIVE = (READY) AND (REMOTE) AND (DIPEN)
where READY = (DRIVEOK) AND (SWEN)

READY: flag that indicates the drive is free of faults and ready to hardware enable

DRIVEOK: switch indicates the status of the drive faults.

SWEN: switch indicates the status of the software enable (EN or DIS).

REMOTE: switch indicates the status of the hardware Remote Enable line on the C3 connector.

DIPEN: switch indicates the state of the DIP enable/disable switch (#8)

Ready Flag		
DRIVEOK (fault status)	**SWEN (software enable)**	**READY (drive ready)**
0 (fault exists)	0 (disable)	0
0 (fault exists)	1 (enable)	0
1 (no faults)	0 (disable)	0
1 (no faults)	1 (enable)	1

Active Flag			
READY (drive ready)	**REMOTE (hardware enable)**	**DIPEN (DIP switch enable)**	**ACTIVE (power to the motor)**
0	X	X	0 (no)
X	0	X	0 (no)
X	X	0	0 (no)
1	1	1	1 (yes)

If the drive will not enable, check the state of the switches and flags by clicking the “Status” button in the upper right-hand corner of the Main **MOTIONLINK** screen. If using a terminal, you can query the drive for the value stored in the STATUS variable (refer to *VarCom Reference Guide* for an explanation on STATUS parameters). The Status Display indicates an enabled drive when the decimal point is illuminated solid.

SERCOS INTERFACE SETUP

The SERVO**STAR** PD comes with SERCOS interface communication capability. It must be ordered from the factory with this option. The Encoder Equivalent Output D9 connector (C4) is replaced with two fiber-optic ports, transmitter (Tx) and receiver (Rx).

This section provides the SERCOS-specific information needed to complete the installation and setup of a SERCOS interface SERVO**STAR** drive to the fiber-optic ring.

DIP SWITCH CONFIGURATION

DIP switch configuration is similar to that of the standard SERVO**STAR** drive. Through these switches, the drive's address and communication power levels are set.

Setting Drive Address

Up to 31 SERVO**STAR** drives can be configured on the SERCOS ring. The first five switches of the DIP set the drive address. When the address is zero (00000), the drive operates as a SERCOS repeater and as a single-axis unit with serial communication. You can monitor and configure the drive through the serial port. Any other address setting, 1-31 (00001 – 11111), establishes the drive as an active SERCOS ring participant with communications through the Tx/Rx ports. When the drive has a non-zero address, you can communicate through the serial port only for monitoring purposes.

Setting Transmission Power Levels

The SERCOS transmitter power level (DIP switch 9) should be set according to the expected signal attenuation between a SERCOS transmitter and the next receiver. Signal attenuation is based upon cable length, cable type, and intermediate connection losses (e.g. bulk head connectors). The following table may be used to calculate the maximum allowable and minimum required signal attenuation for a given power level and cable attenuation:

Power Level Attenuation Specifications		
Attenuation	**Low Power**	**High Power**
Maximum	9.5 dBm. + 2 m. *Ac	12.5 dBm. + 2 m. *Ac
Minimum	-	1.5 dBm. + 2 m. *Ac
***Note**: Ac = Fiber optic cable attenuation in dBm./m.*		

The maximum and minimum cable lengths may be calculated by dividing the maximum and minimum signal attenuations by the cable attenuation. The following table shows the cable lengths for 1 mm plastic fiber with an attenuation of 0.18 dBm/m:

Cable Length Specifications		
Length	**Low Power**	**High Power**
Maximum	54.7 m	71.4 m
Minimum	-	10.3 m
1) Fiber optic cable attenuation is 0.18 dBm/m. *2) Cable length calculations assume that the fiber is not attenuated by intermediate connections.*		

For most applications, the low power setting is sufficient. Longer cable runs or the use of intermediate connectors may require the high power setting. Communication problems may occur if the power level at the receiver is too large or too small. Receiver power problems may cause erroneous data transfer resulting in the drive returning to CP0, or failure to advance out of CP0. For more information on SERCOS interface signal attenuation, refer to the following sections of the IEC 61491 SERCOS interface specification:

1. 5.3 - Optical Signals on the Transmission Line
2. Annex G: Attenuation on the Transmission Line

STATUS DISPLAY

After the CP run-up sequence has completed, the drive is in OPMODE 5 when communicating on a SERCOS ring. This is indicated by the number "5" on the Status Display. The SERCOS version of the SERVO**STAR** differs from the standard unit in that errors and faults are not communicated through this display (only through the SERCOS ring to the controller). Therefore, if an error occurs, the "5" remains on the display. The Status Display decimal point turns ON and OFF when the drive is enabled or disabled.

The SERCOS interface version of the SERVOSTAR is not automatically enabled on power-up, no matter what the address.

CONNECTION

The mating connector selected for the Tx and Rx ports follow the IEC 874-2 specification, which recommends an F-SMA type connector. A hand-tight connection is adequate. Danaher Motion Kollmorgen offers 30, 60, and 100cm plastic fiber optic cables with SERCOS interface-compatible F-SMA connectors. The following specifications provide general cable information:

Cable Characteristics	Specifications
Cable Type	1mm plastic
Attenuation	≤0.18dBm/m
Fiber NA	.47
Temperature	-55ºC to 85ºC
Jacket material	PVC
Jacket OD	2.2 ± 0.07mm
Tensile Strength	7kg

Also refer to IEC 61491 specifications 5.2.2 Structure of the Transmission Lines, 5.3.3 Fiber Optic Cable, and 5.3.4 Connectors for more connector and cabling information.

COMMUNICATIONS

The SERVO**STAR** PD offers two communication approaches for drive configuration. The first approach is to communicate via a multi-axis SERCOS controller all the drive parameters through the fiber-optic ring during the CP2 and CP3 run-up stages. This requires a broad understanding of the controller functionally and knowledge of the SERCOS interface standard and manufacturer's IDN set. The standard and manufacturer IDNs supported by Danaher Motion Kollmorgen are functionally categorized to make this configuration method easier.

The second approach allows you to configure each axis separately through the serial port using **MOTIONLINK**. **MOTIONLINK** guides you through the setup stages of the configuration process. It provides interactive setup screens for easy manipulation of the drive's parameters, while giving you realtime monitoring and recording tools to optimize axis performance. The parameters can be stored in the drive's EEPROM memory before establishing communication through the SERCOS interface.

Drive Configuration

Before you can begin the CPx (where x = 0,1,2,3,4) run-up process, the drive should be configured and tuned for the axis of operation using the steps below:

1. Power down the drive.
2. Set the drive address to zero for single-axis operation.
3. Select a serial baud rate.
4. Connect a serial cable from the drive to a host.
5. Power up the drive
6. Install **MOTIONLINK** and communicate with the drive.
7. Follow the user screens to configure the drive and motor combination.
8. Enable the drive.
9. Tune the system as desired.
10. Save the drive parameters to EEPROM.
11. Power down and reset that actual DIP address. Any non-zero address will set the drive up for communication on the SERCOS ring. Each drive on the ring must have a unique non-zero address.
12. Set the SERCOS baud rate (DIP switch 6 off/on for 2/4Mbits/s)
13. Depending on the ring configuration, link the fiber optic cables from drive-to-drive or drive-to-master as follows: Tx1 to Rx2, Tx2 to Rx3, etc.
14. Power up the drive. It is now prepared to ascend through the SERCOS communication phases under the master's control.

CP Run-up

Upon power-up, the Status Display should alternately flash a "P" and a "0" to indicate SERCOS interface communication phase 0. As the drive ascends through each communication phase, the display will alternately flash a "P" and a number indicating the next sequential communication phase (phase 0-4). Upon reaching communication phase 4 (CP4), the display will briefly flash "P" and "4" before displaying a steady state "5". This indicates that SERCOS interface has been initialized and the drive and motor system is ready for commanding motion.

CP2 Initialization

IDN 18 contains a list of IDNs that must be written to the drive in CP2. The CP2 transition procedure (IDN 127) verifies the drive's readiness to transition from CP2 to CP3 and checks whether each IDN listed in IDN 18 has been written by the master. If any IDN has been written with illegal values, the drive will not transition to CP3. If the drive fails to transition, IDN 21 contains a list of improperly configured IDNs. The following IDNs should be configured during CP2:

IDN	Description	Notes
2	Communication cycle time (tncyc).	Must be 2000µs
6	AT transmission starting time (t1).	
9	Position of data record in MDT.	
10	MDT length.	
89	MDT transmission starting time (t2).	

Some masters do not support toggling the control unit synchronization bit (MDT control word, bit 10) during CP3 and CP4. In this case, initialize the control unit synchronization bit monitoring IDN (P152) to 0 during CP2. Refer to the IDN descriptions for more information.

CP3 Initialization

IDN 19 contains a list of IDNs that must be written to the drive during CP3. If the drive was properly configured using **MOTIONLINK**, IDN 19 should be empty and the master requires no IDN initialization during this phase.

Operational Notes

1. Remember that the hardware enables, DIP switch 8 and the Remote Enable line must be enabled before the drive can be system enabled through the MDT control word during CP4. If system enabling fails, refer to IDN P15 for a list of conditions that prevent this action.
2. If a fault occurs, the drive will not allow the master to clear faults while any of the MDT control bits (13-15) are set.
3. SERCOS Torque Units:
4. Standard SERCOS torque units are based on 0.1% of motor continuous current. However, when using **MOTIONLINK**, the torque units are based on 0.1% of drive peak current.
5. SERCOS Velocity Units: counts/CUCT * 256

The following formulas may be used to convert to and from the SERCOS interface units and rpm.

Vel {rpm} = Vel {cnts/CUCT * 256} * 1875 / (8 * cnts * CUCT)
Vel {cnts/CUCT * 256} = Vel {rpm} * 8 * Cnts * CUCT / 1875

Equation Notes

1. Cnts = the number of encoder (or resolver equivalent) counts per revolution.
   Where: Encoder counts = Encoder lines * 4.
   Resolver counts = 2^16 * MResPoles/2
2. CUCT = The control unit cycle time (IDN 1) in ms.
3. The units "CUCT/ms" is the number of CUCT periods per mS. For example, a 2 ms CUCT has 1/2 a CUCT per 1 ms.
4. Remember the following when monitoring a SERCOS drive through the serial port:
   - The SERCOS interface address is also the serial communications address.
   - SERCOS interface operation changes the UNITS variable to internal units.
   - The SERCOS interface version of the SERVO**STAR** is not automatically enabled on power-up, even with the drive address set to 0.

SYSTEM OPERATION

The SERVO**STAR** PD has a seven-segment indicator, called a Status Display that indicates four types of states: Power-up, Steady State, Flashing State, and Momentary State. The decimal point directly relates to the global drive enable.

Status Display	
DRIVE STATE	**DISPLAY APPEARANCE**
Power-up	Momentarily illuminates all display segments (forming an 8) and the decimal point.
Steady State (No Faults)	Displays the operational mode (OPMODE) of the drive (0-8).
Flashing State	Used to indicate an abnormal operating state: If the position hold feature is active, the OPMODE number will flash at a 1 Hz rate. If a fault was detected, a flashing code will be displayed to identify the fault. Some codes consist of a sequence of two or more digits (see Troubleshooting section). In general, these faults will cause a latched disable (sometimes controllable through software switches). To clear fault, toggle remote enable (except for OverCurrent). If the encoder initialization function (ENCSTART) is active, the OPMODE number will flash at a 3 Hz rate.
Momentary Fault	Displays a character momentarily for 500 ms before returning to the steady state. The timer is resetable. C = Communications Error F = Drive is in FoldBack mode

Status Display Decimal Point	
Decimal Point State	**Drive Status**
Steady OFF	No power to the motor
Steady ON	Drive enabled, power to the motor
Flashing	Drive enabled, power to the motor, but a motor safety feature has been disabled (for example, LIMDIS = 1).

OPERATIONAL MODES

The SERVO**STAR** PD has the ability to assume different modes of operation. It is factory configured in OPMODE 1 (Analog Velocity Controller) but may be reconfigurd. Not all commands and variables are active or meaningful in every OPMODE.

1. Serial Velocity Controller (OPMODE = 0): the SERVO**STAR** PD is configured as a velocity-loop controller and is controlled by issuing a velocity command (J: jog command, or STEP: step command) to the drive via the serial port.
2. Analog Velocity Controller (OPMODE = 1): the SERVOSTAR PD is configured as a velocity-loop controller and is controlled through either a ±10 V analog input signal or jog (J) commands stored in the Configurable I/O. The commanded velocity is proportional to the input voltage.
3. Serial Torque (Current) Controller (OPMODE = 2): the SERVO**STAR** PD is configured as a torque-loop controller and is controlled by issuing a current command (using the T command) to the drive via the serial port.
4. Analog Torque (Current) Controller (OPMODE = 3): the SERVO**STAR** PD is configured as a torque-loop controller and is controlled via a ± 10 V analog input signal. The commanded current is proportional to the input voltage.

5. Gearing Position Controller (OPMODE = 4): the SERVO**STAR** PD is configured as a positioning controller that can operate in one of three settings (Encoder Follower, Pulse/Direction, Up/Down Counter). The setting used is determined by the GEARMODE variable.
6. Position Controller (OPMODE = 8): the SERVO**STAR** PD is configured as a serial or an analog positioning controller, depending on the value of PCMDMODE, that can receive simple absolute, incremental, indexing, homing, and analog commands.
7. SERCOS interface Controller (OPMODE = 5): the SERVO**STAR** PD must be ordered from the factory as a SERCOS interface unit to establish communications in this OPMODE. The drive is shipped with Connector C4 as the Transmit/Receive port (no longer the Encoder Equivalent Output).

DRIVE CONFIGURATION

The drive functionality is set using various drive parameters and instructions communicated over the RS232 serial port. Refer to the VARCOM manual for a complete list and description of these instructions. The parameters are stored in non-volatile memory in the drive, to be used on power-up. **MOTIONLINK** is used to configure the drive.

FIRMWARE VERSION

The firmware version is obtained by entering the VER instruction. In response, the drive returns a string that is similar to:

```
Kollmorgen Motion Technologies
ServoStar PD: ENCODER
5.0 Amp continuous; 10.0 Amp peak rating
Firmware version 6.3.3
Runtime: 0:27:30
```

This response indicates the current rating (in Ampere RMS).

Always know the firmware version when calling for technical support.

DRIVE ENABLE

The drive is enabled by a combination of 3 signals and states:

- The Remote Enable is a hardware signal generated by the motion controller (24Vdc applied between pins 6 and 7 of connector C3)
- The Software Enable is generated by one of the serial port instructions (EN).
- The drive can be enabled only when no faults exist. If a fault exists, a code describing that fault is displayed on the 7-segment LED.

When the drive is enabled, the decimal point in the display is lit. If the decimal point is flashing, this indicates that the user has disabled some safety-related feature. A typical example is when the drive is programmed to ignore limit switches (LIMDIS = 1).

SYSTEM I/O

The SERVO**STAR** PD has three digital inputs and one digital output that can be configured to a variety of functions. This section discusses the I/O features of the C3 connector (except for the thermostat input on C2). Refer to the *VarCom Reference Guide* for details.

Analog Input (ANIN)

The position, velocity, or torque loop can receive its command from an analog voltage source and is selectable through the OPMODE variable. The analog input to the SERVO**STAR** PD is differential. This means the signals received at the two inputs are subtracted from each other to create a 'difference', which is used to command the rest of the system. This type of input has a high degree of noise immunity and, in many cases, allows for ground isolation between systems. This analog input also has a low pass filter (ANLPFHZ) to prevent high frequency noise from entering the system.

The input voltage from the differential receiver is applied to a precise 14-bit Analog-to-Digital (A/D) conversion system. The A/D conversion system is read by the microprocessor every 500µS for the position loop modes, every 250 µs for the velocity loop mode, and every 62.5 µs for the torque (current) loop mode of operation. Encoder-based units come with the additional benefit of a Dual Gain (ANDG) input. When enabled, the system uses two 14-bit A/D inputs to read the user-supplied analog signal. One input is a direct reading of the ± 10V signal, while the other incorporates a 2x gain term. When the input voltage is less than 4 V, the 2x channel is used to determine the input voltage, which extends the resolution to a 15-bit equivalent. Above 4 V, the system uses the straight 14-bit conversion. Special software algorithms are used to minimize cross-over distortion and add 0.25 V of hysterisis.

Analog systems often require scaling and offset bias. The SERVO**STAR** PD adds an analog offset (ANOFF) variable to this reading, performs an analog deadband (ANDB) adjustment, and scales it through the either the position loop input scaling (GEARI, GEARO), velocity loop input scaling (VSCALE), or torque loop input scaling (ISCALE) before passing the data to the selected control loop. The analog input (ANIN) variable indicates the analog reading after the offset (ANOFF) and the deadband (ANDB) adjustments but before the loop scaling. The ANIN variable range is ± 22500 counts (or mV).

The SERVO**STAR** PD also offers an automatic analog input zeroing function. Invoking the ANZERO command while the drive is enabled or disabled samples motor velocity over a 32 ms period and updates ANOFF accordingly to the analog input offset. This command also incorporates an internal offset mechanism that has finer resolution than ANOFF is capable of providing.

Remote Enable Input (REMOTE)

The opto-isolated Remote Enable input (REMOTE) provides a hardware drive enable switch. This 12 VDC to 24 VDC input disables or enables the power stage output to the motor. The signal must be customer-supplied in order to get the drive to enable (in combination with other parameters; ACTIVE) and operate. Tapping the signal off the logic supply (P1) is possible, but is not recommended. The toggling of this switch will also initiate an attempt to recover from a fault condition. It can also be used to trigger various position homing features (HOMETYPE).

Configurable Inputs (IN1, IN2, IN3)

These 12 VDC to 24 VDC inputs are defined by the INxMODE variable. Placing the appropriate value in INxMODE (See the *VarCom Reference Guide* for details) sets up the inputs to be used for such features as CC/CCW hardware position limits, Electronic Gearing, serial and analog position triggering (for incremental moves and homing), fault output relay configuration, **MOTIONLINK** scope triggering, and more. When set for the CC/CCW hardware position limits, the inputs prevent any further motor travel in their respective direction but do not disable the drive or prevent motion in the opposite direction. ***If acceleration control is in place (PROFMODE = 1), the motor ramps to a stop after the opening of the End Travel Limit***. These inputs are opto-isolated and considered "active enable", meaning current must flow through these signals to allow the system to operate. This provides a 'dead-man' safety feature. Energizing both the CW and CCW hardware position limits causes the SERVO**STAR** PD to enter the HOLD mode. These inputs can also be inverted (ININVx, where x = 1, 2, 3).

The default settings of these inputs are for the hardware position limits. The Status Display may flash an 'L' upon power-up indicating that a travel limit has been tripped. If these position limits are not in use, set LIMDIS=1.

Configurable Digital Output

The digital output (O1, O1MODE) can be toggled in an On/Off state to indicate various drive, motor, and variable conditions. These include: absolute speed and current levels, FoldBack conditions, motor braking, motion complete and zero speed conditions, position overshoot flagging, programmable limit switch detection, and an enable (ACTIVE) flag. Condition, reset, and triggering levels are established through O1MODE, O1RST, O1TRIG.

Fault Output Relay (RELAY, RELAYMODE)

The SERVO**STAR** PD provides a drive ready/drive up output in the form of a relay (RELAY) output. The relay (RELAY) output is controlled by the SERVO**STAR** PD's microprocessor. There is a software switch (RELAYMODE) that configures the relay (RELAY) output to act as a 'Drive Ready' or 'Drive Up' indicator:

1. If RELAYMODE = 0, the relay is closed when the drive is error free and ready to run. This is a 'Drive Ready' configuration.
2. If RELAYMODE = 1, the relay is closed only when the drive is enabled. This is a 'Drive Up' configuration.
3. If RELAYMODE = 2, the relay opens during a fault when the drive is disabled.

You can program this fault output to open on any system fault by triggering the Configurable Inputs (IN1MODE, IN2MODE, IN3MODE, IN1, IN2, or IN3).

Motor Thermostat Input (THERM, THERMODE)

The SERVO**STAR** PD provides a motor thermostat input on the C2 connector that is configured for different types of thermal protections (THERMTYPE), as well as manipulating of how the drive responds to a motor thermal condition (THERM, THERMODE, THERMTIME). Kollmorgen **GOLD**LINE motors and cables connect the thermostat through the feedback cable. The input to the SERVO**STAR** PD is electrically-closed through the thermostat for proper operation. The drive normally flashes an 'H' in the Status Display when this input is electrically opened.

If a motor thermal device is not used, set THERMODE to 3 to disable the feature (turns the 'H' status display indicator off).

SINE/COSINE CALIBRATION

Overview

The software Sine Encoder and software Resolver algorithms are based on sampling the incoming sine and cosine signals. Although the process is transparent to the user, and therefore does not require additional commands, the accuracy of the process depends on the sampling accuracy of the sine and cosine values. In order to prevent accuracy degradation due to electronic component tolerances, the sine and cosine values must be gain- and offset-compensated.

The process of finding the gain and offset compensation parameters is called “Sine Zero”. The process matches an amplifier to an encoder or resolver, and hence must be done after replacing a motor or an amplifier. After the process terminates the gain and offset values are stored in the non-volatile memory and are loaded each time the amplifier is powered on.

The process includes finding 128 maximum and minimum, Sine and Cosine peaks and calculating the average gain and offset values. Due to accuracy restrictions the motor must be rotated at a slow speed so that the Sine/Cosine waves generated will be at a frequency low enough for a valid result. The speed must be such that the frequency of the Sine/Cosine signals does not exceed 250Hz. For a rotary motor, the maximum motor speed in RPM can be calculated from

60 x 250 / (MENCRES x MSININT)

For a linear motor, the maximum motor speed in mm/sec can be calculated form

250 x MPITCH / (MSININT x MENCRES)

The Process

During calibration the motor can be moved manually or under servo control (preferably under velocity control). The following steps should be taken:

1. Initialize the process by entering the instruction *SININIT* (without parameters)
2. Move the motor in either direction. While moving the motor, query the status using the *SININIST* instruction.
3. The process is complete when *SININIST* returns a value of 3 (done) or 5 (fault).
4. Use the *SINPARAM* instruction to query or set the sine calibration values. There are four calibration parameters when working with a Sine Encoder, and six calibration parameters when working with a Resolver.

ENCODER INITIALIZATION WITHOUT MOTION

Overview

In brushless 3-phase motors the torque generated by the motor depends on the three phase currents and on the motor position. In order to properly control the motor and extract maximum torque out of the available motor and power stage, the controller must be provided with the current motor position. In encoder-based systems, the initial position for commutation initialization may be found using hall sensors switching, index finding, or an appropriate commutation-lock algorithm (or a combination of the three methods).

In system that do not have hall sensors, Encoder Initialization without motion uses a commutation-lock algorithm.

Since, on power up, the absolute motor position is unknown, two methods may be implemented:

- Applying a forced commutation to move the motor to a predetermined position where the torque generated is zero and updating controller variables accordingly.
- Using a motion control algorithm that will "bring" the commutation angle of the motor from the initial, unknown position to the current motor position (instead of moving the motor).

The first method described is currently implemented on the SERVO**STAR** CD. The disadvantage of this method is that it requires the motor to be moved, which produces a "jumpy" motion that may not be tolerable in some cases (for example - linear motors applications).

The second method is designed to solve this problem by implementing a closed loop commutation-lock algorithm that adjusts the commutation angle to the motor position rather than moving the motor to a predetermined place. The motor will move very slightly; motion of at least ±4 electrical degrees is expected.

The Process

1. Disable the drive
2. Select the encoder initialization process by entering the instruction *INITMODE 2*
3. Set the encoder initialization current using the *IENCSTART* instruction. Set this to the maximum allowed application current.
4. Set the gain for the process using the *INITGAIN* instruction. This gain is typically set to 1000.
5. Set the correct value for the motor inertia using the *MJ* instruction.
6. Initialize the process by entering the instruction *ENCSTART*
7. Begin the process by enabling the drive
8. Monitor the process by reading the status word *STATUS2* and the status of *ACTIVE*

If the process completes successfully, the drive will be enabled, and *ACTIVE* will be set to 1. If the process is not successful, bit 2 in the first word of *STATUS2* will be set.

SOFTWARE RESOLVER INTERFACE

Overview

The resolver-to-digital (RDC) conversion is done in the Series 5 products using software techniques, as opposed to using a dedicated integrated circuit. The benefits of this mechanism include:

- Enhanced system performance, since the resolution is not a function of the velocity.
- Increased accuracy due to the ability to calibrate and match the Sine and Cosine signals
- Increased reliability due to the use of fewer components

The Process

The SW resolver implements a 2nd order tracking filter which uses feed-forward to zero (ideally) the tracking error for constant speed. *RESBW* is the filter bandwidth and the tradeoff is: the higher the bandwidth, the faster the response but the more the system will be prone to noise.

The Sine and Cosine signals of the resolver should be calibrated in order to increase the accuracy of the measurement. The calibration process is described above in the section Sine/Cosine Calibration. This process is initialized automatically at each power up; old parameters are used until the calibration process can generate new parameters. Thus, there is no need to explicitly enter the SININIT instruction.

CORE PROCESSORS

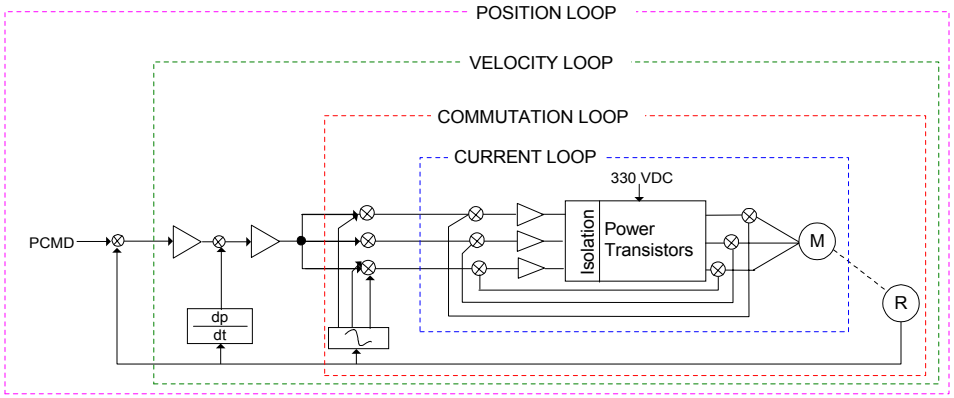
A 40 MHz embedded controller and a 40 MHz DSP controller are the heart of the SERVO**STAR** PD. They use its internal operating system to monitor inputs, adjust outputs, communicate serially, maintain servo control, and monitor faults. The flash memory firmware that controls the core processor and gives the SERVO**STAR** PD its operating characteristics is saved in EPROM. The version number of the firmware can be read using the VER command. When calling Danaher Motion Customer Support for technical support, be sure to have the firmware version number. The most recent version of firmware is available for purchase and is easily field upgradable through a PC. It can be obtained by contacting a Danaher Motion Kollmorgen sales representative or by contacting Danaher Motion Customer Support.

CONTROL LOOPS

This section describes the servo control loops, their characteristics, and how to configure them.

Servo Loop Description

The SERVO**STAR** PD provides high performance motor control by controlling up to four distinct closed loop systems within the DSP: the current, commutation, velocity, and position loops. The next figure depicts the control loops graphically.



Current Loop

Since current and torque are proportional in a Permanent Magnet (PM) motor, the current loop is often referred to as the torque loop. The function of the current loop is to regulate motor current as directed by a current command signal. The current command signal from the microprocessor can either come from a direct user input (OPMODE 2 & 3) or from the output of the velocity loop. There are actually three current loops, one for each motor phase. Each current loop receives its own command input from the commutation loop.

The SERVO**STAR** PD uses a fully digital, pole placement current loop with high bandwidth and a current loop sampling rate of 16 kHz (62.5 µs.). All coefficients of the current loop are digitally calculated inside the drive for a given set of motor and drive characteristics. The current loop also includes adaptive gain terms to compensate for some non-linear effects.

The current loop incorporates electrical isolation for protection from the high-voltage BUS. These current loops also convert the output voltage to a Pulse Width Modulated (PWM) signal providing the highest efficiency possible. The PWM center frequency can be 8 or 16 kHz according to the drive size.

Commutation Loop

This loop converts a single-phase current command signal into a three-phase, position-modulated sine wave input to the current loops. The SERVO**STAR** PD has a patented sinusoidal wave form generator that uses Torque Angle Advance to get top performance out of its motors. The waveform generator is part of the microprocessor and is updated at a 16 kHz rate. This provides hi-fidelity sinewave commutation at both low and high velocities. The sinewave output must be aligned to the back EMF (MOTORBEMF) characteristics of the motor, making resolver or encoder alignment to the motor is critical.

Velocity Loop

The purpose of the velocity loop is to regulate motor speed. Like the current and commutation loops, the velocity loop is fully digital and uses the resolver or the encoder feedback signals to calculate actual motor velocity. The command for the velocity loop can come from either a direct user input (OPMODE'S 0&1) or the output of the position loop. The velocity loop is a digital sampling system operating at 4 kHz.

The difference between actual and desired velocity is filtered through a compensator algorithm and fed to the commutation loop. The SERVO**STAR** PD offers four velocity compensators (methods of regulating velocity) selectable through the COMPMODE variable. The four are: Proportional-Integral (PI), Pseudo-Derivative-Feedback with Feed-Forward (PDFF), Standard Pole Placement, and Extended Standard Pole Placement.

Position Loop

The final control configuration is the position loop. The purpose of this loop is to maintain motor shaft position. Like the previous loops, the position loop is fully digital and uses resolver, encoder, and sine encoder feedback signals to determine actual motor position. The drive can also accept a position signal from an external feedback device (e.g., load encoder). It samples at a rate of 2 kHz and can be configured for three different modes of operation:

OPMODE 4: This mode of operation sets the SERVO**STAR** PD up to run as a pulse (or master encoder) follower by using the Electronic Gearing feature. The pulse input can either be applied through the Configurable Inputs on the C3 connector (up to 2.5 KHz max. - opto-isolated) or through the Remote Encoder Input on the C8 connector (up to 3 MHz) on top of the drive.

OPMODE 8: This mode of operation configures the SERVO**STAR** PD as a simple positioning controller. Once in this mode, position commands can be given through the serial port, through the Configurable I/O, or through the analog input (determined by the PCMDMODE variable). The position loop has been enhanced to a full PID controller with acceleration and velocity feed-forward gains. Two integral gain variables have been added to limit the action of the integral term during selected parts of the profile. This helps to minimize overshoot and settling problems.

Using a serial command (**PCMDMODE=0**), the SERVO**STAR** PD executes simple absolute, incremental (or indexing), and homing motion profiles. This is done either by direct commands through the serial port (MI, MA, MH) or by pre-configuring a profile in memory to be used in conjunction with the Configurable I/O (MASPEED, MISPEED0-3, MAPOS, O1, O1MODE, INx, INxMODE).

Using an analog command (**PCMDMODE=1**), the SERVO**STAR** PD scales the analog input (GEARI, GEARO) to establish a wide range of relationships between an analog input adjustment and a corresponding shaft movement. Homing types (HOMETYPE) are available that home to a particular analog input level (and position count), triggering either through the Configurable Inputs or the Remote Enable.

In this mode of operation, the drive can also accept an external load feedback signal through the C8 connector (**DUALFB=1**). This helps eliminate the positional inaccuracies, due to gear backlash and poor coupling, by positioning according to the load's position (not the motor shaft's position). The SERVO**STAR** PD also operates in the position mode when the drive is in the hold position state (**HOLD=1**).

Torque Loop Operation

The design of the control loops was discussed in the previous section. Now, the operation as a system is presented. The SERVO**STAR** PD has many internal variables that are used to examine and dictate system operation. Many of these variables and their locations in **MOTIONLINK** are presented graphically in the following discussions to help disclose meanings and relationships.

Serial Torque

The SERVO**STAR** PD can be operated as a serial torque-controlled amplifier (OPMODE 2). It receives a serial command (T) via a host to a command generator, which in turn creates a current command (ICMD). The current (or torque) command is checked against peak (IMAX, ILIM) and continuous (FoldBack features, ICONT) current clamp limits. Sinusoidal commutation modulation is added to the command and then fed to the three-phase current loop regulator, which calculates a current error. This error is then fed through a digital pole-placement compensation algorithm. The output of the compensator is converted to a PWM signal and fed to the power transistor bridge. The power bridge uses the high voltage DC Power Supply (typical 325 VDC bus) to supply the required current to the motor windings. The actual motor current is updated and the process begins again.

Analog Torque

The SERVO**STAR** PD can be configured to operate as an analog torque loop controller (OPMODE 3). In this case, the current loop receives its input from the analog-to-digital (A/D) conversion system. After conversion, the input command signal is processed through an algorithm which adjust the signal (ANOFF, ANDB, ANZERO), filters it (ANLPFHZ) and then scales it (ISCALE), before developing the current command (ICMD). The current (or torque) command is then checked against peak (IMAX, ILIM) and continuous (FoldBack features, ICONT) current clamp limits.

Sinusoidal commutation modulation is added to the command and then fed to the three-phase current loop regulator, which calculates a current error. This error is then fed through a digital pole-placement compensation algorithm. The output of the compensator is converted to a PWM signal and fed to the power transistor bridge. The power bridge uses the high voltage DC Power Supply (typical 325 VDC bus) to supply the required current to the motor windings. The actual motor current is updated and the process begins again.

Current Sampling

The current loop receives corrective feedback from the current sampling circuitry. The current sensors use closed-loop hall sampling techniques in all units.

The current sample is used by the current loops to regulate the current in each of the three motor phases. Two phases (A and C) of the current signal are sampled by the microprocessor at a 16kHz rate. The momentary A phase current and C phase current can be monitored by examining the IA and IC variables, respectively. The microprocessor calculates the equivalent absolute current, which can be monitored as I. This value can be averaged for 2, 4, 8, 16, 32, or 64 samples.

Foldback

The SERVO**STAR** PD offers two types of FoldBack protection for both the motor and the drive. The drive's microprocessor monitors the current feedback signal and develops a RMS value of this signal for the purpose of providing a value that represents the current in the motor. The system is similar to an "I-squared-T accumulator.

Drive FoldBack

This FoldBack algorithm monitors current feedback and, if the feedback exceeds the continuous current rating of the drive/motor combination (ICONT), will decrease the system's current to the ICONT level. For example, under a step command input condition, the FoldBack algorithm will allow maximum peak current (IMAX) output from the drive for 2 seconds (or ½ second for Cx units). After two seconds, the drive enters "FoldBack mode" (FOLD=1) and begins an exponentially FoldBack to the system's continuous current. It takes approximately six seconds for the exponential decay to drop from the system's peak current to its continuous level.

For drive currents that exceed ICONT, but are below IMAX, the system period before FoldBack occurs is extended beyond two seconds. Two seconds is the shortest time period that will elapse before the drive enters FoldBack and only occurs when maximum peak current (IMAX) is drawn. This FoldBack feature is designed to protect the drive electronics, not the motor. The Configurable Output, O1, (pin 12) can be configured to indicate a drive FoldBack condition.

Motor FoldBack

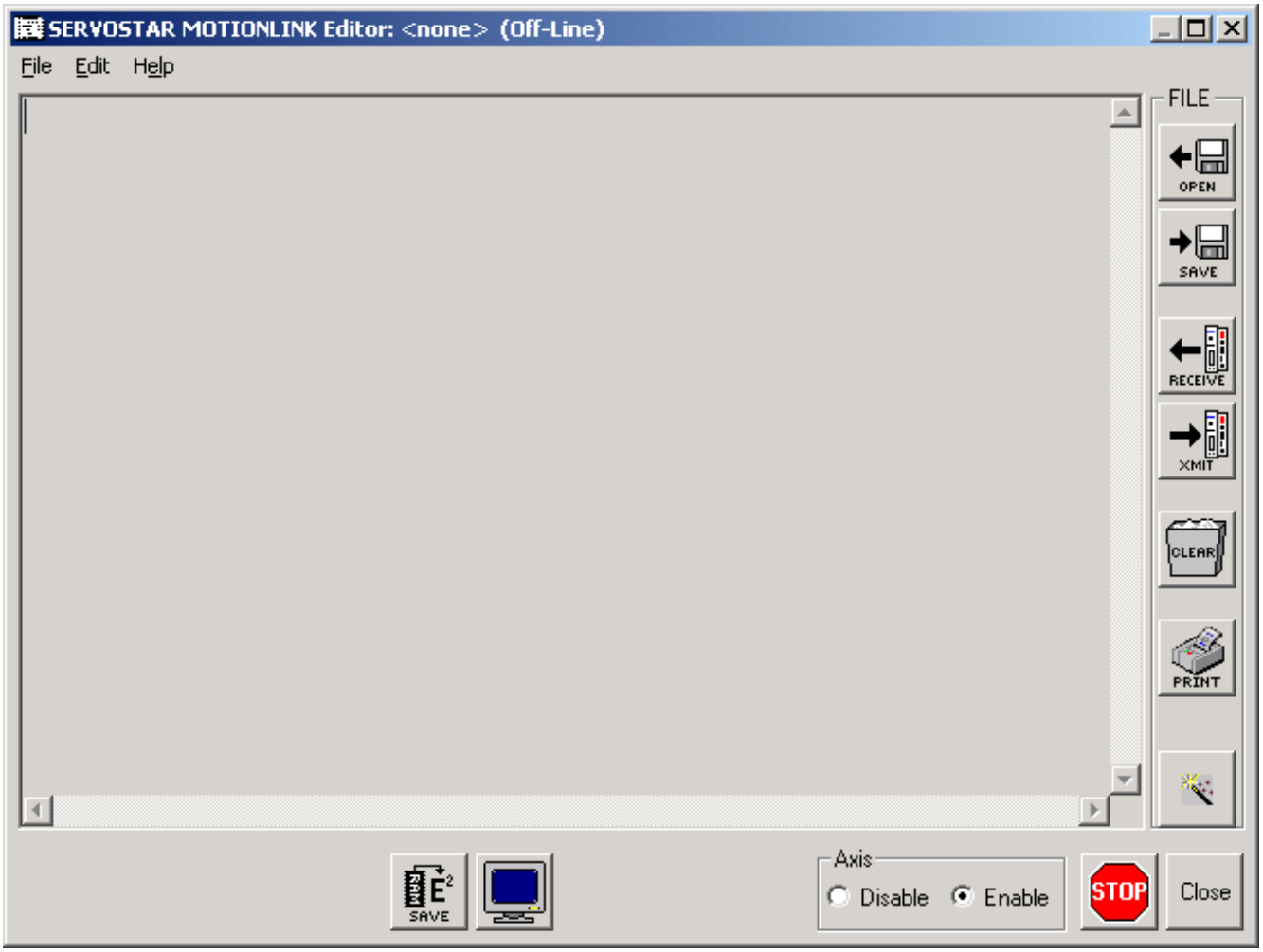
The FoldBack algorithm is designed to provide motor protection in cases where the drive's continuous current rating is above the motor's continuous rating. This combination is often desired in applications where maximum peak motor torques are required. However, the possibility exists that the drive could source current on a continuous basis indefinitely to the motor and would force it beyond its thermal capability. Unlike the drive FoldBack, you have complete configurability over this feature (MFOLD, MFOLDD, MFOLDDIS, MFOLDR, MFOLDT).

FIRMWARE UPGRADE PROCEDURE

PREPARATIONS

Retrieve Drive Parameters

Using **MOTIONLINK**, go the Drive Backup screen. Click on the Receive button to get the parameters from the drive. Then, click on the Save button to save the file to disk.



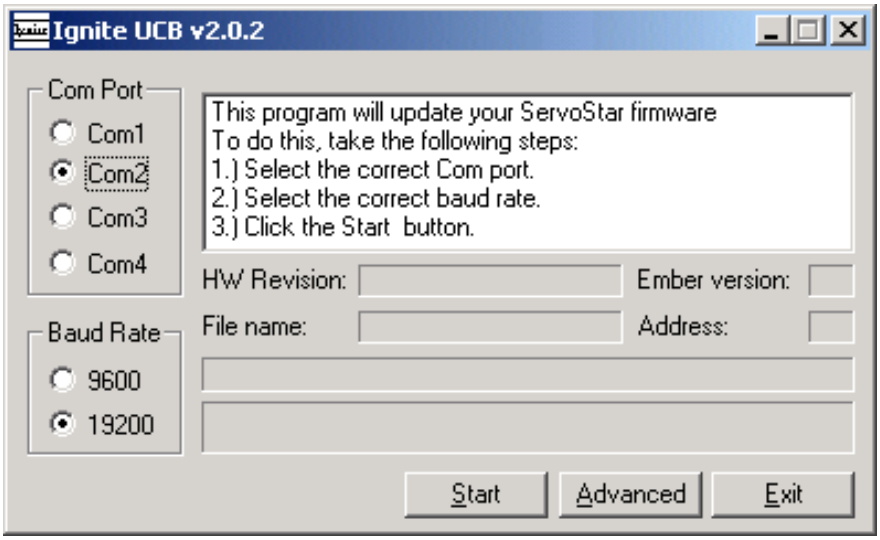
Clear the Drive Parameters

Clear the drive parameter memory. Go to the Terminal, and enter the instruction CLREEPROM. Exit from **MOTIONLINK**.

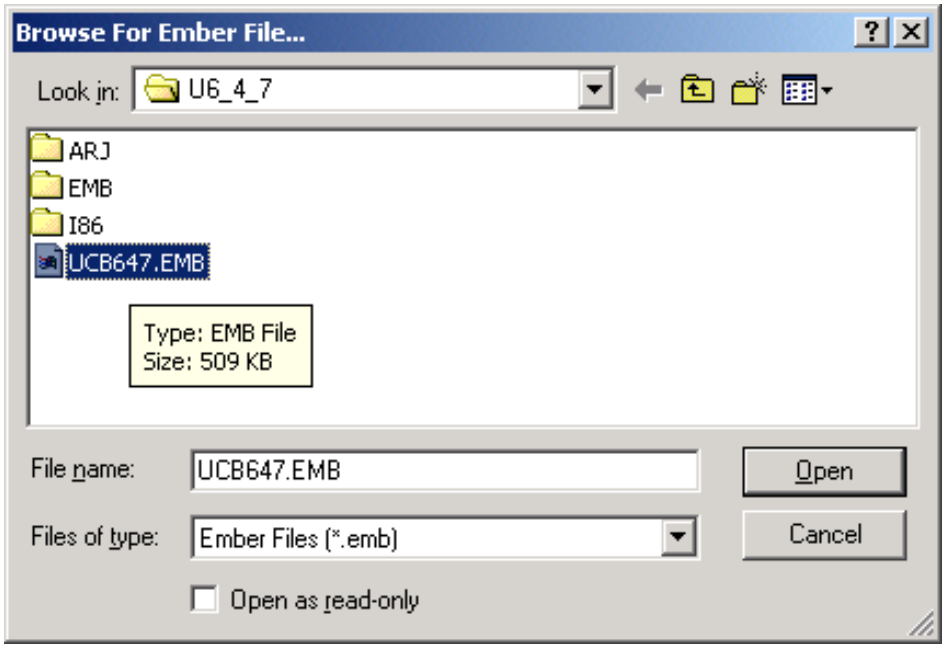
UPDATE DRIVE FIRMWARE

Download the Firmware

Use the WINIGNITE program to download the new firmware. This is a Windows program. Run the program; the following screen appears:

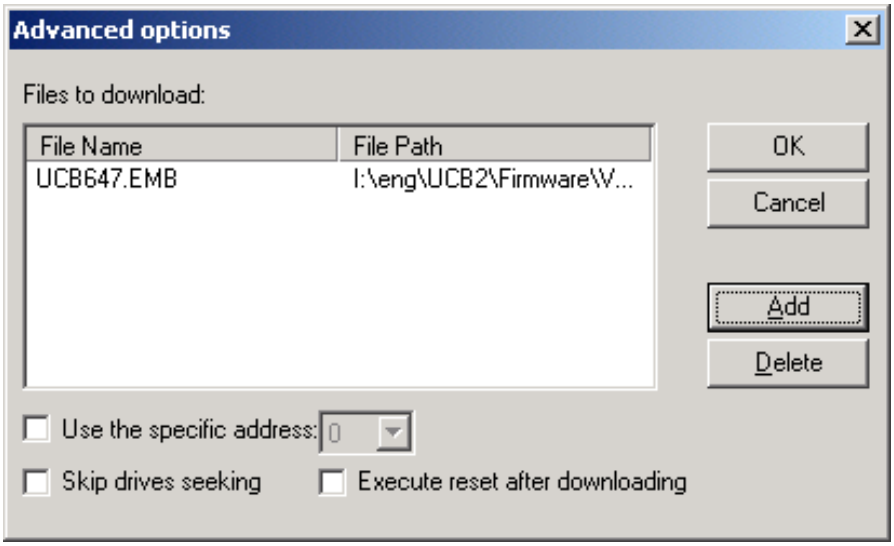


1. Select the correct Com port.
2. Select the correct baud rate (try use 19,200 so that the process will be faster). Make sure that the DIP switch 6 is set to match the baud rate you select here.
3. Click on the Advanced button. Click on the Add button, to select the file to be downloaded. For example:

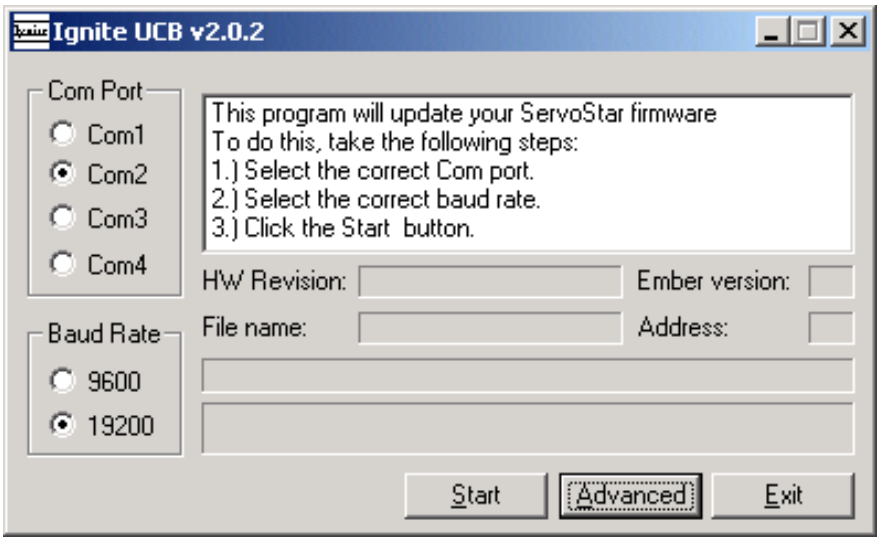


4. Select the correct **.EMB* file.

5. Click on *Open*, and return to the *Advanced Options* screen.



6. Select the *EMB* file, and click on *OK*.
7. Now click on the *Start* button to start the firmware download.



Cycle Power

Once the download is finished, cycle drive power.

Connect to the drive with MotionLink. From the Terminal screen, type in the *VER* instruction, and verify that the drive firmware version is as expected.

TROUBLESHOOTING

The 7-segment display on the front of the drive indicates the status of the drive. When the drive is disabled and there are no faults, the display is blank. When the drive is enabled, the decimal point is lit.

ERROR LEVELS

The SERVO**STAR** PD responds to an error according to the error's severity. The three levels of severity are:

1. Errors that cause warnings. These are called Errors.
2. Errors that disable the system and indicate fault status. These are called Faults.
3. Errors that disable almost all the SERVO**STAR** PD functions (including communications). These are called Fatal Errors.

LED DISPLAY

The SERVO**STAR** PD has a LED Display that provides a quick visual indication of the status of the amplifier. When a fault condition occurs, the drive is disabled and the LED displays the cause of the fault so you can readily determine the source of the problem. Faults are cleared by removing the cause of the fault, and then toggling the drive enable signal. The drive over-current fault (P) can only be cleared by cycling the drive power. Refer to the table of fault display codes in the following pages.

Display States

The display has three types of states: Steady State, Flashing State, and Momentary State.

Steady State - A number is displayed to indicate the mode of operation (set by the OPMODE command). The steady state display indicates no errors are detected. The number displayed indicates the following OPMODES:

0 - Serial Velocity Mode
1 - Analog Velocity Mode
2 - Serial Torque Mode
3 - Analog Torque Mode
4 - Gearing Mode
5 - Reserved
6 – Reserved
7 – Reserved
8 - Position Mode
9 - Reserved

Flashing State - A letter is displayed to indicate an abnormal operating state. If the position hold feature is active, the display flashes its operational mode number. For a fault, a letter displays indicating a fatal error condition or state. In general, these faults cause a latched disable (some latches are controlled by software switches). You can attempt to reset the fault (except OverCurrent) by removing the remote enable and then re-asserting it or by software disable (K, DIS, or S) and then re-enabling it (EN).

Momentary State - A letter is displayed (for at least 500 ms) to indicate a momentary fault condition. The display then returns to its appropriate state. The timer is resettable. The letter displayed indicates the appropriate fault in the following table:

Display	Description
	Communication Error: This fault indicates there is a problem with serial communications. This is typically a framing error, overrun error, baud rate or parity error etc. This is not a latched error.
	Foldback: This fault indicates the current to the motor is higher than what the drive can deliver for an extended period of time. The drive is self-protecting for its rated current level. Peak current to the motor is allowed for two seconds. After the two seconds, the drive folds-back (limits) the current to the motor to protect the drive. This condition is a self-resetting error.

Decimal Point

The decimal point directly relates to the global drive enable. The states are:
Steady Off - No power to the motor.
Steady On - Drive is enabled and power on the motor.
Flashing - Drive is enabled, power is on the motor, but some safety feature has been disabled (the motor thermostat input has been disabled, or limit switches have been disabled). This is not considered a fault.

FAULTS

The following provides a description of some of the more important faults detected by the PD:
Motor Over-temperature: The motor's thermostat input is monitored for an open circuit condition.
Drive Over-temperature: The internal heat sink temperature is monitored for an unsafe condition. The fault is reset only after the drive cools.
Bus Over-voltage: This fault occurs during a regen operation where the BUS is raised to higher values than that produced by the power supply.
Bus Under-voltage: This fault occurs if the incoming line voltage drops or if a problem occurs in the power supply.
Power Stage Fault (Over-current): Hardware circuitry monitors load short-circuit, transistor failure, and instantaneous over-current. A power stage fault cannot be reset by toggling the enable line — only by cycling the power.
Feedback Loss: Hardware detects a wire-break condition in encoder based systems.
Power Supply Under-voltage: Hardware monitors the internal analog ±12 VDC supply for out-of-tolerance voltages.
In addition to the Status Display and LEDs the PD also sends error codes with a text message to the serial port. The same message is saved in non-volatile memory in an error history log. (See FLTHIST.)

Fault Logging

In addition to the status display, LEDs, and the serial notification of errors, the SERVO**STAR** PD also records the error message in non-volatile memory for later review. Each entry into the error log has an associated error code number as defined in the tables below. The SERVO**STAR** PD stores the ten most recent faults in the Fault History Buffer. To display the entire Fault History, type:

FLTHIST This causes the fault history to be sent via the serial port to the terminal, with the most recent fault sent first.

FLTCLR Used to clear the fault history .The fault history Buffer remains even through power-down.

ERR Displays the last error generated

The PD responds with the last (most recent) fault in the fault history not previously transmitted and the last error.

Fatal Error Codes

Fatal Error Codes			
Error Code#	**Status LED**	**Associated Text Message and Meaning**	**Possible Cause**
1	E	Power Stage Over-Temperature	Overload, fan malfunction, or power stage failure.
2	O	Over Voltage	Excessive decel rate can cause voltage regeneration.
3	P	Power Stage Over current	Power stage short circuit.*
4	r	Feedback Loss	Bad feedback connection.
5	U	Under Voltage	Bus voltage is too low. The bus voltage may not be connected or powered up.
6	H	Motor Overheat	Motor overload caused overheating or a bad connection
7	A	Analog (±12V) Supply	Internal ±12 volts power supply fault.**
8	J	OverSpeed	Software detected motor overspeed. The application overspeed limit is set by the VOSPD parameter.
9	E	EEPROM Failure	Faulty EEPROM. **
10	P E	EEPROM Checksum	Drive parameters have not been saved. Execute the SAVE command.
11	=	Watchdog Fault	Drive failure.* Can be caused by an unexpected drive condition. Consult the factory.
12 -		No Compensation	The CONFIG instruction has not been executed. Do so after entering all the motor data.
13	F	Foldback	Load requiring too much RMS current
14	I	RAM Failure	RAM test failure (display will not flash).**
15	C	EPROM Checksum	Faulty code EPROM (display will not flash).**
16	b	Bad Power Stage Code	Internal hardware failure. **
17	L	Limit Switch Open	A limit switch input to the system (CWLIM or CCWLIM) has been activated.

* These faults can only be cleared by cycling power

** These faults usually indicate an internal failure, necessitating repair or replacement of the unit. Consult with the factory.

Non-Fatal Error Codes

Error Code	Fault Message	Possible Cause
0	No Error	No error was recorded
20	Unknown Command	Undefined command
21	Unknown Variable	Undefined variable name
22	Checksum Error	Error on comm. message checksum (ACKMODE 2)
23	Drive Active	Drive needs to be inactive for the requested command or variable
24	Drive Inactive	Drive needs to be active for the requested command or variable
25	Value Out of Range	Variable value out of range
26	Value Negative	Variable must be ≥ 0
27	Not in Proper OPMODE	Not in correct operational mode for specified command
28	Syntax Error	Communication message syntax error
33	Auto Tune Failed	Auto-tuning failed
34	Bad Bandwidth	Auto-tuning bandwidth parameter is out of range
36	Not Programmable	Variable is Read Only
37	Invalid Configuration	Drive not configured; no compensation
38	Communication Error	Error at physical comm. layer
39	Not in Proper COMPMODE	REFRESH command given with COMPMODE not equal to 3
40	EXT Velocity Parameter Warning	D, H, R parameters for COMPMODE 3 do not have the proper relationship to each other.
41	Vel Loop Design Failed	Velocity loop could not be configured with the given parameters
43	Recording Active	Requested command cannot be executed because it conflicts with a recording in process
44	Rec Data not Available	No data available for the GET Command
45	EEPROM is Empty	Data cannot be loaded because the EEPROM is empty
46	Argument Must be Binary	Requested value is not in the set of acceptable parameters
47	BURNIN is Active	Requested function cannot be executed during BURNIN (a factory function)
48	BURNIN is not Active	BURNIN (a factory function) cannot be stopped if it is not active
49	Conflicts with ENCOUT	Requested value for VLIM conflicts with the value of ENCOUT
50	Conflicts with VLIM	Requested value for ENCOUT conflicts with the value of VLIM
51	Not Available	Requested variable value or command is not available; refer to its detailed description in the *VarCom Reference Manual* to determine the cause.
52	Drive is in Hold Mode	Motion was requested while the drive was in Hold mode.
53	Limit Switch Hold	Drive is in Hold mode due to limit switch being tripped
54	Command into Limit	Requested motion is in direction of tripped limit switch
55	Drive is in Zero Mode	Motion requested while in Zero mode
56	Motor is Jogging	TUNE command cannot be executed because motor is jogging
60	Tune failed-no rotation	TUNE command failed because motor could not rotate
62,66 70,74	Tune failed-current sat	TUNE command failed because the current loop saturated
63,67 71,75	Tune failed-no vel design	TUNE command failed because the vel loop could not be designed
76	Disable During Tune	TUNE command failed because drive was disabled while tuning
77	Hold During Tune	TUNE command failed because drive entered Hold mode while tuning
78	Low Velocity Limits	TUNE command failed because VLIM is too low
79	Use Lower Bandwidth	TUNE command requires a lower bandwidth in order to execute